Dynamical Variability of Ozone near the Tropopause from AIRS Data

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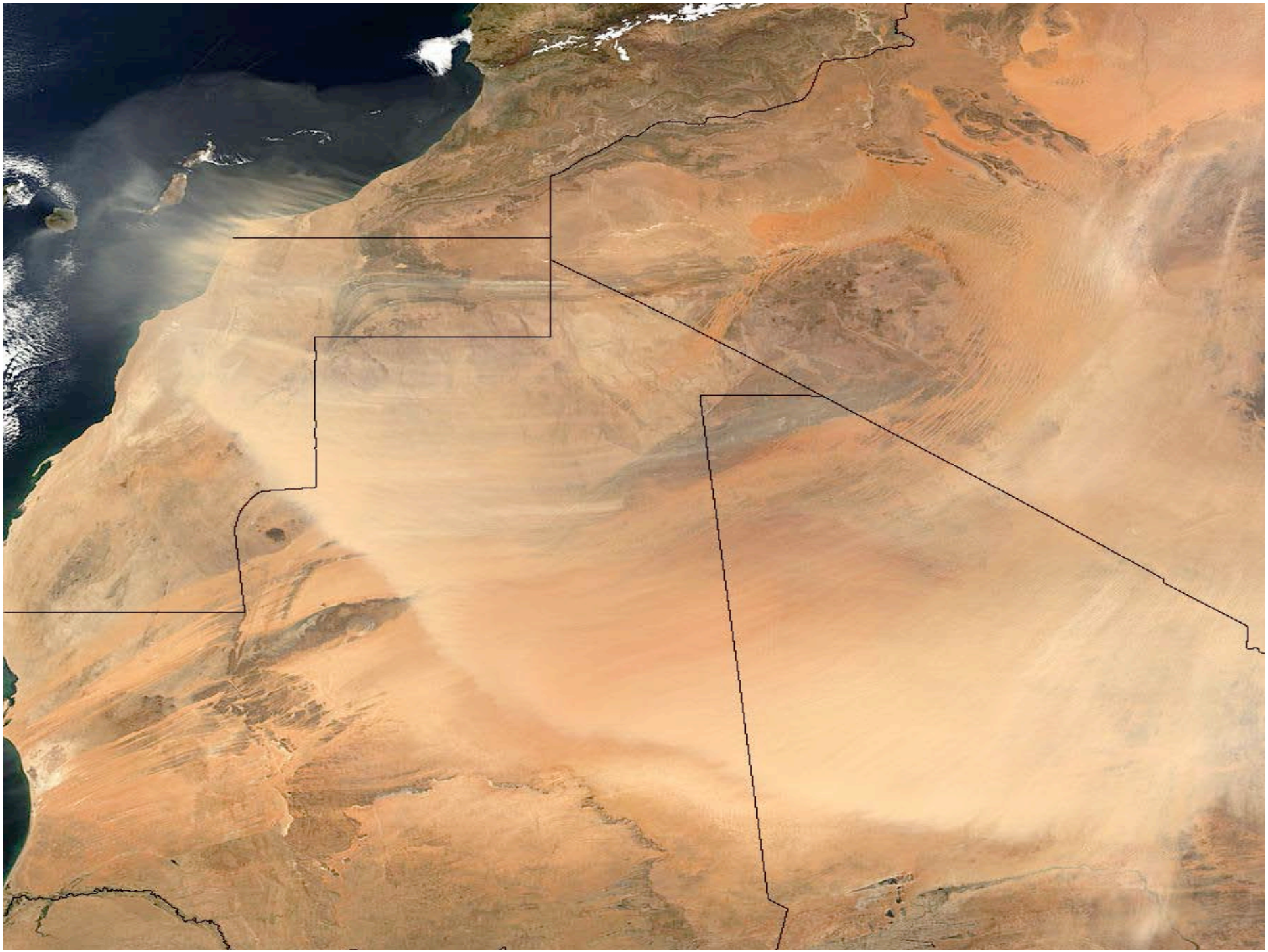
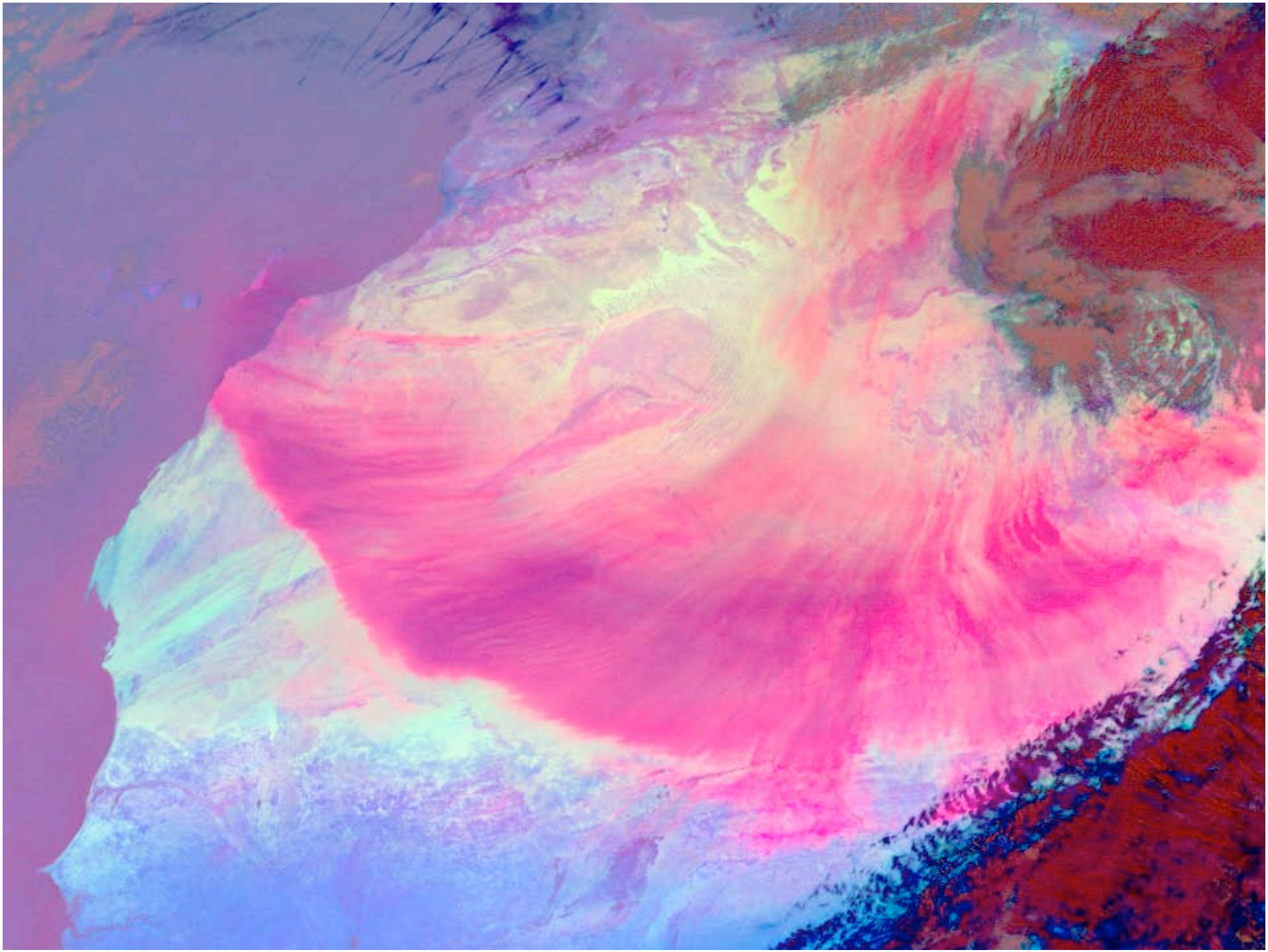
AIRS Ozone Data

- Continue to show impressive consistency with dynamics of the UTLS – case 5
- Validation study continues –
  - Using ozonesonde data
  - Using aircraft data (MOZIAC)
- Dynamical variability – Preferred locations of Stratosphere to troposphere transport (STT) of ozone

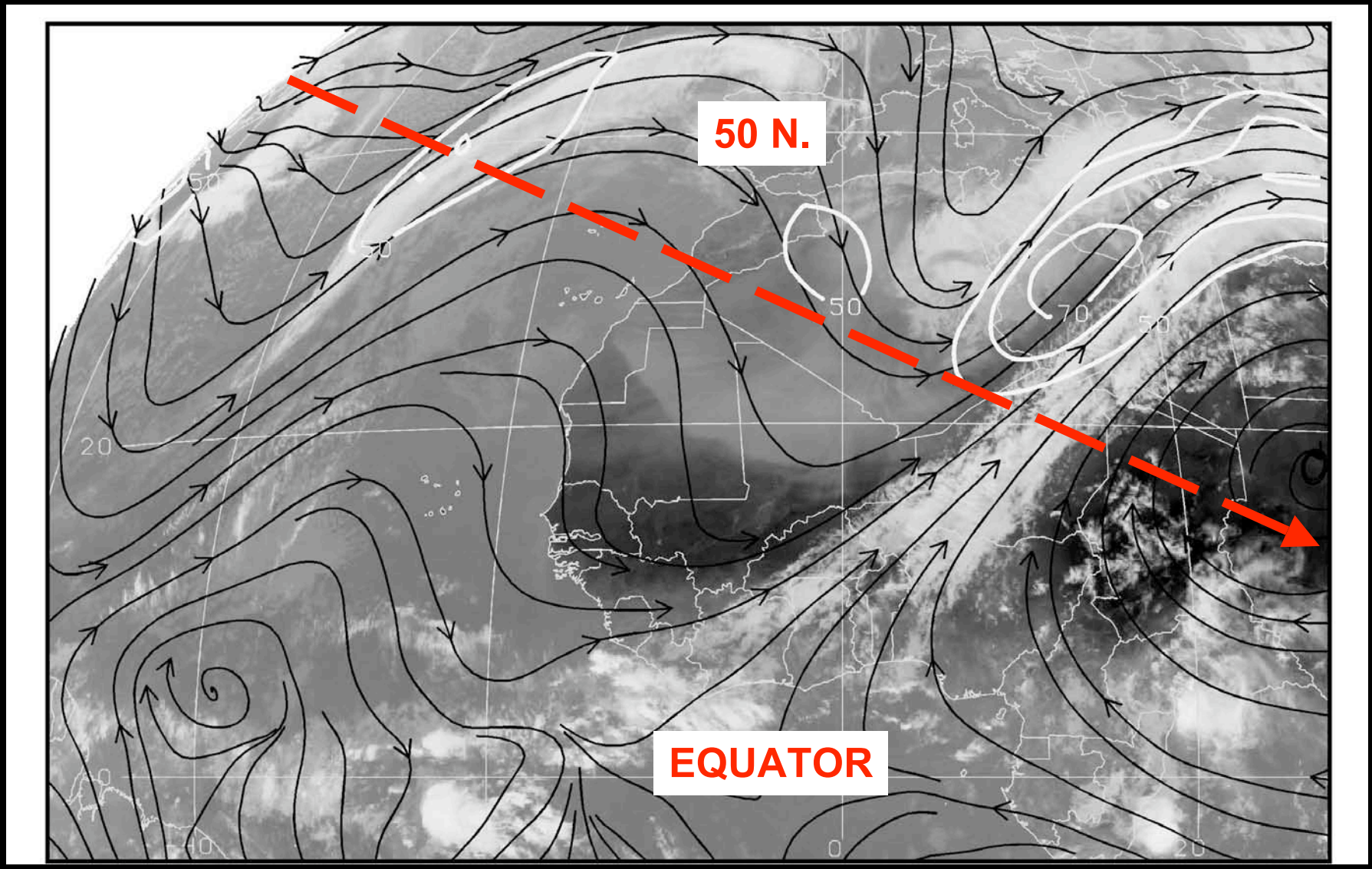
Case 5: Stratospheric Intrusion during a Dust Storm

In collaboration with Mel Shapiro and Hsiao-ming Hsu

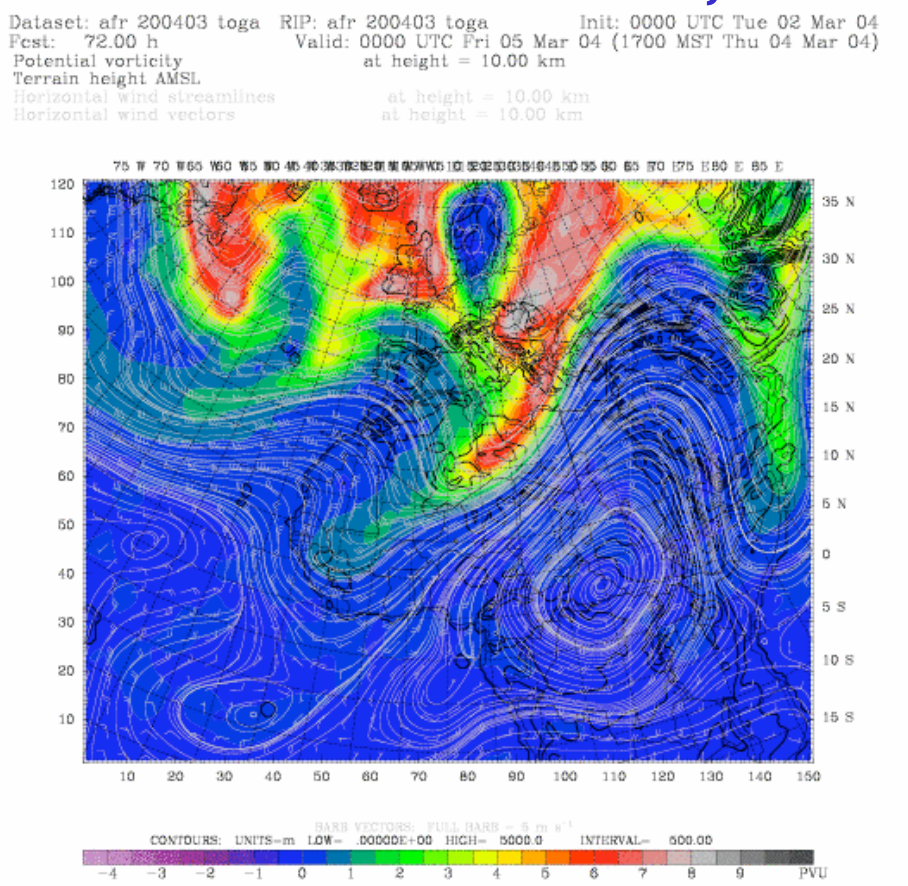


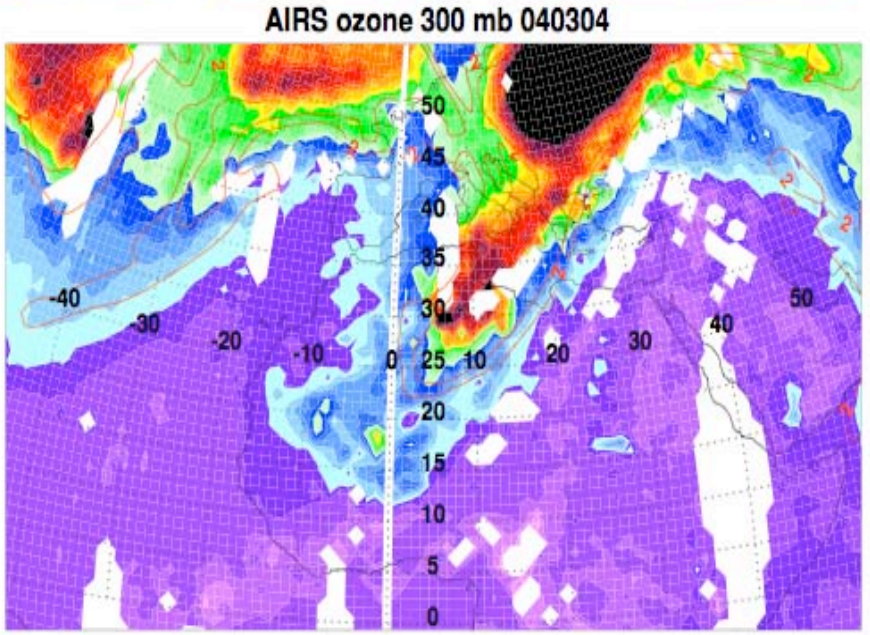


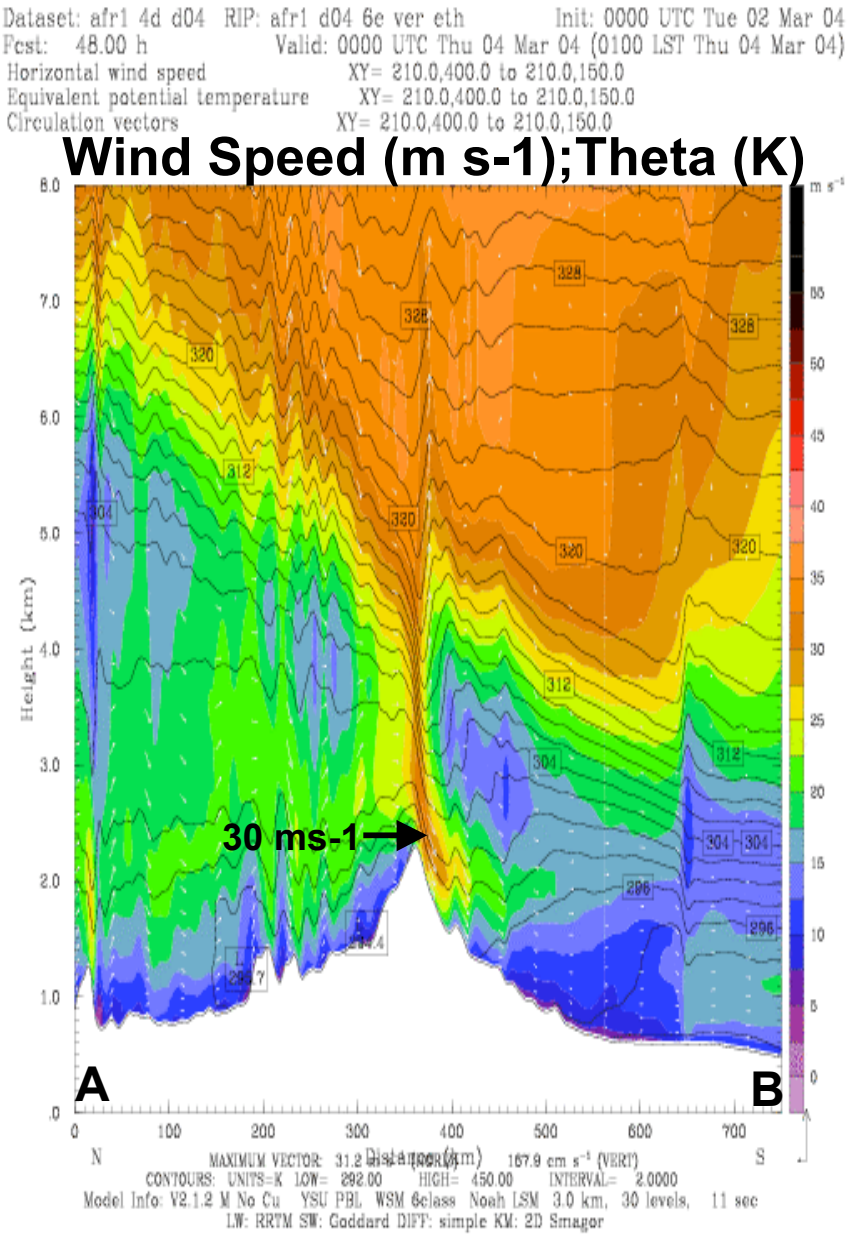
Rossby Wave-Train Ray Path

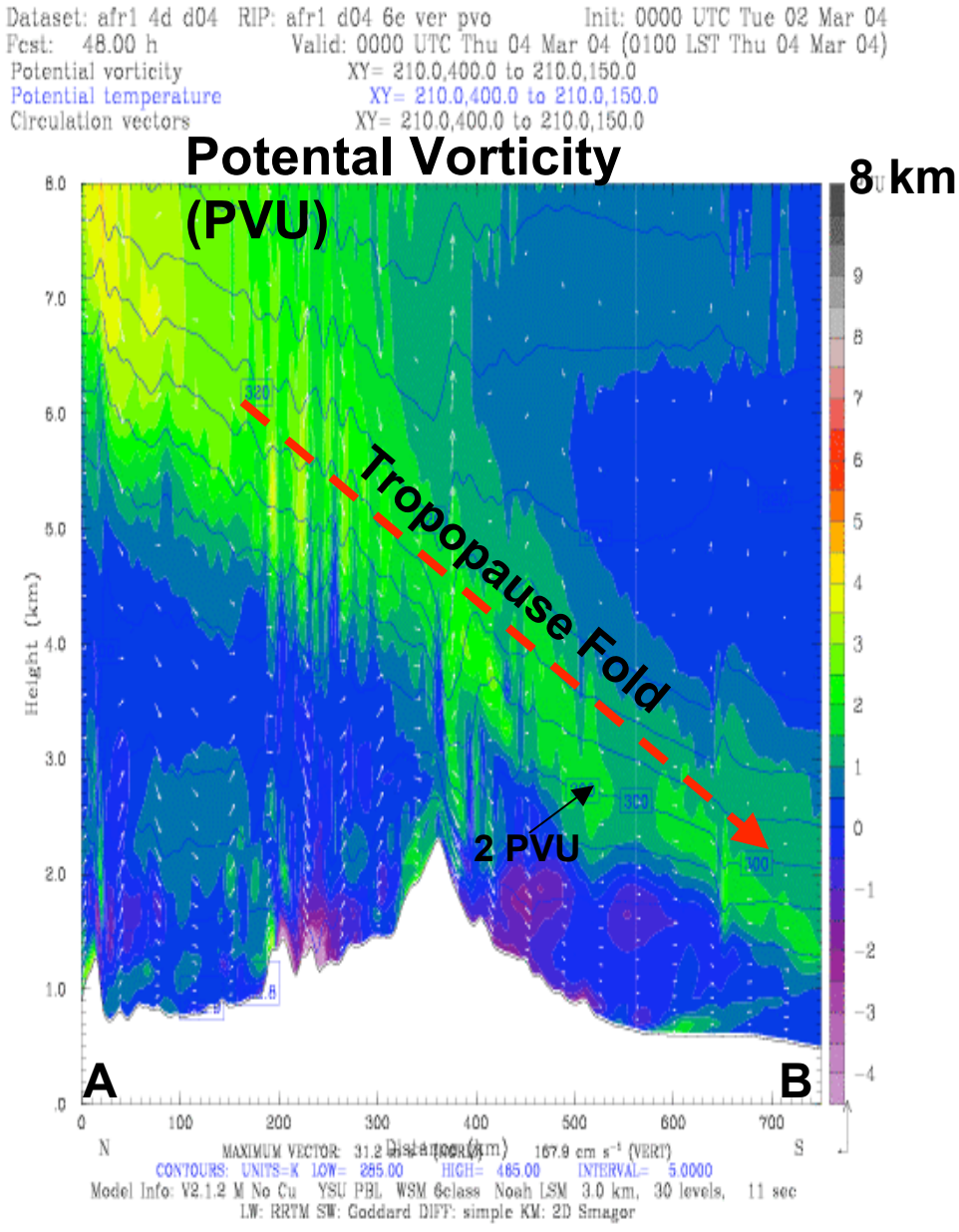


PV from NCAR WRF/ARW model and AIRS Ozone, March 4th, 2004

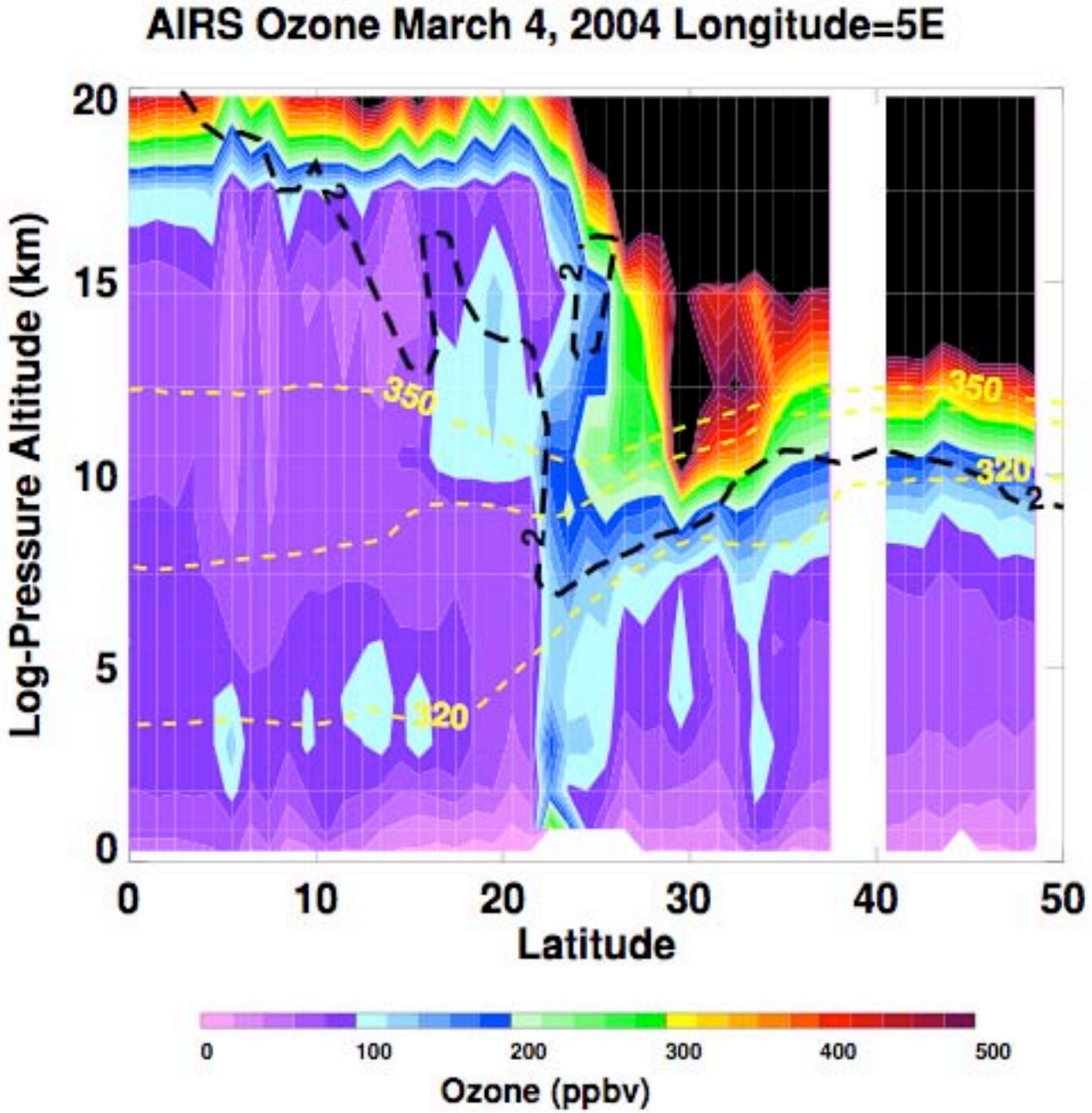




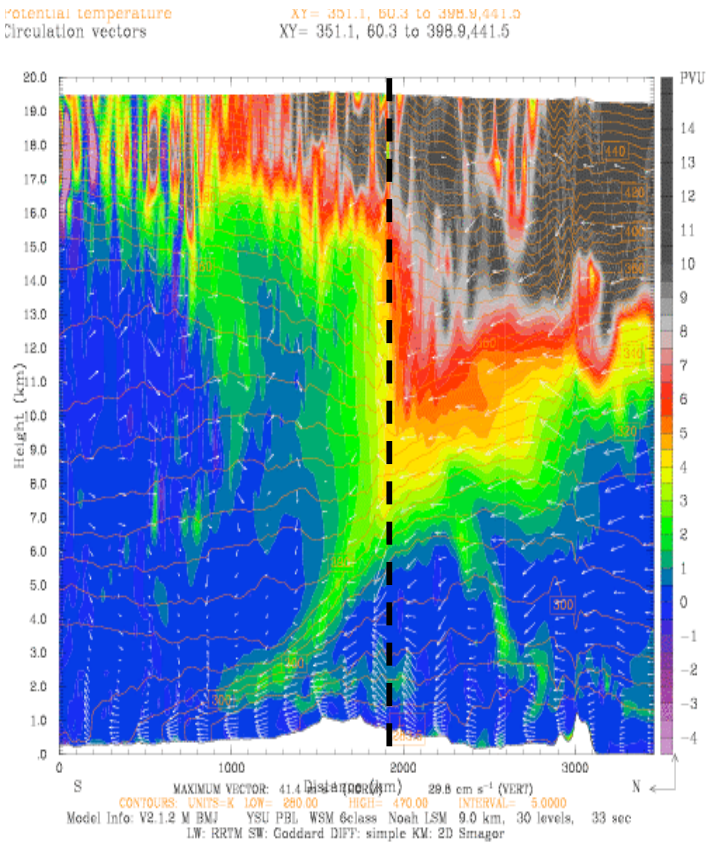

Dataset: afr1 4d d04 RIP: afr1 d04 6e ver eth Init: 0000 UTC Tue 02 Mar 04
Fcst: 48.00 h Valid: 0000 UTC Thu 04 Mar 04 (0100 LST Thu 04 Mar 04)
Horizontal wind speed XY= 210.0,400.0 to 210.0,150.0
Equivalent potential temperature XY= 210.0,400.0 to 210.0,150.0
Circulation vectors XY= 210.0,400.0 to 210.0,150.0
Wind Speed (m s-1);Theta (K)
30 ms-1
A
B
Height (km)
Distance (km)
MAXIMUM VECTOR: 31.2 m s-1 (HORIZ) 167.9 cm s-1 (VERT)
CONTOURS: UNITS=K LOW= 292.00 HIGH= 450.00 INTERVAL= 2.0000
Model Info: V2.1.2 M No Cu YSU PBL WSM 6class Noah LSM 3.0 km, 30 levels, 11 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

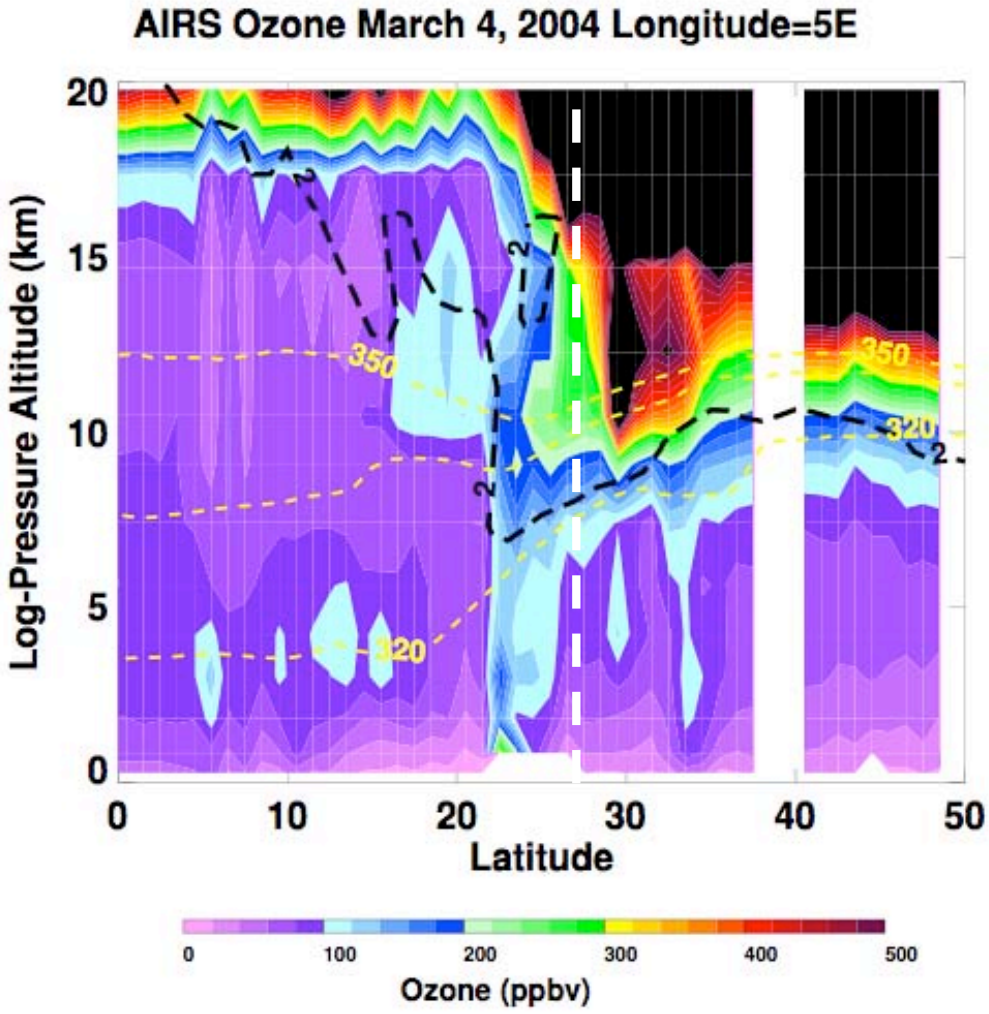

Dataset: afr1 4d d04 RIP: afr1 d04 6e ver pvo Init: 0000 UTC Tue 02 Mar 04
Fcst: 48.00 h Valid: 0000 UTC Thu 04 Mar 04 (0100 LST Thu 04 Mar 04)
Potential vorticity XY= 210.0,400.0 to 210.0,150.0
Potential temperature XY= 210.0,400.0 to 210.0,150.0
Circulation vectors XY= 210.0,400.0 to 210.0,150.0
Potental Vorticity
(PVU)
8 km
Tropopause Fold
2 PVU
A
B
Height (km)
Distance (km)
MAXIMUM VECTOR: 31.2 m s-1 (HORIZ) 167.9 cm s-1 (VERT)
CONTOURS: UNITS=K LOW= 285.00 HIGH= 465.00 INTERVAL= 5.0000
Model Info: V2.1.2 M No Cu YSU PBL WSM 6class Noah LSM 3.0 km, 30 levels, 11 sec
LW: RRTM SW: Goddard DIFF: simple KM: 2D Smagor

Ozone from AIRS on NASA Aqua Satellite



PV from NCAR WRF model and AIRS Ozone cross section





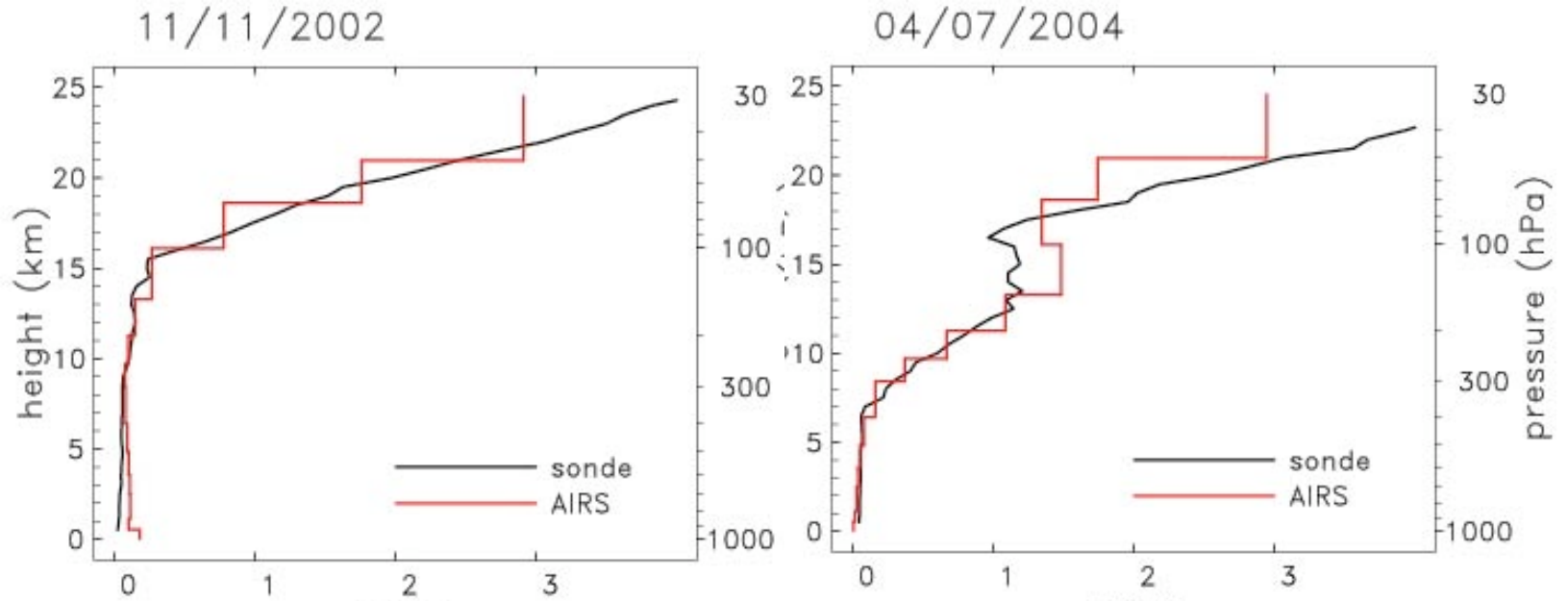
3D ozone structure near the tropopause from AIRS – if validated, it will provide unprecedented opportunities for quantitative studies of STE

We need to understand where the retrieval information is from

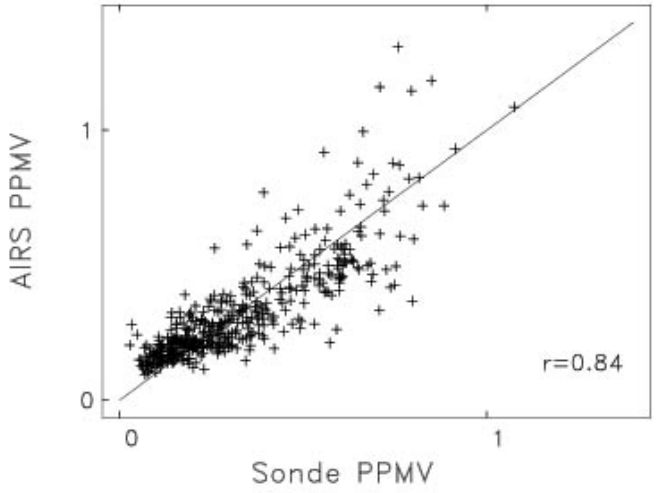
More Validation Studies

- For our own validation studies, we have compared AIRS ozone with ozonesondes and aircraft data (HIAPER and MOZAIC).
- The comparisons shown here use AIRS v4 retrievals, gridded to daily grids with 1x1 degree resolution
- Ozonesondes profiles are taken from the WOUDC archive
- MOZAIC comparisons are in an early stage (preliminary results here)

There are examples of excellence agreement between AIRS ozone profiles and ozonesondes.

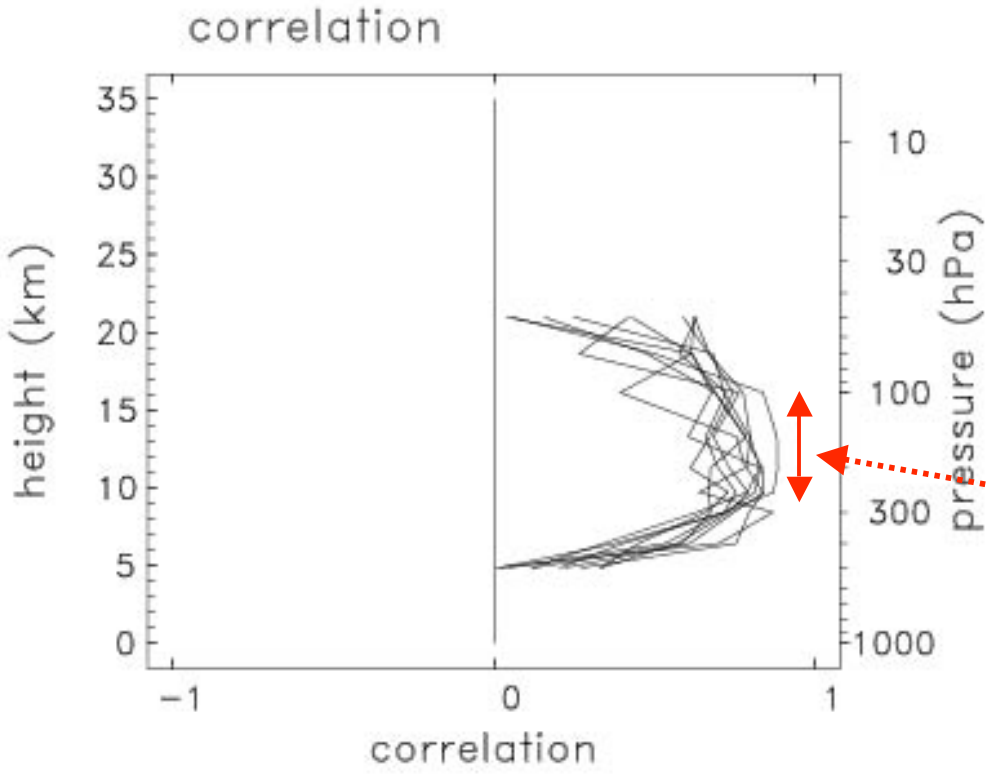


(200hPa ozone, using 442 soundings during 2003-2005)



Payerne, Switzerland (47N)

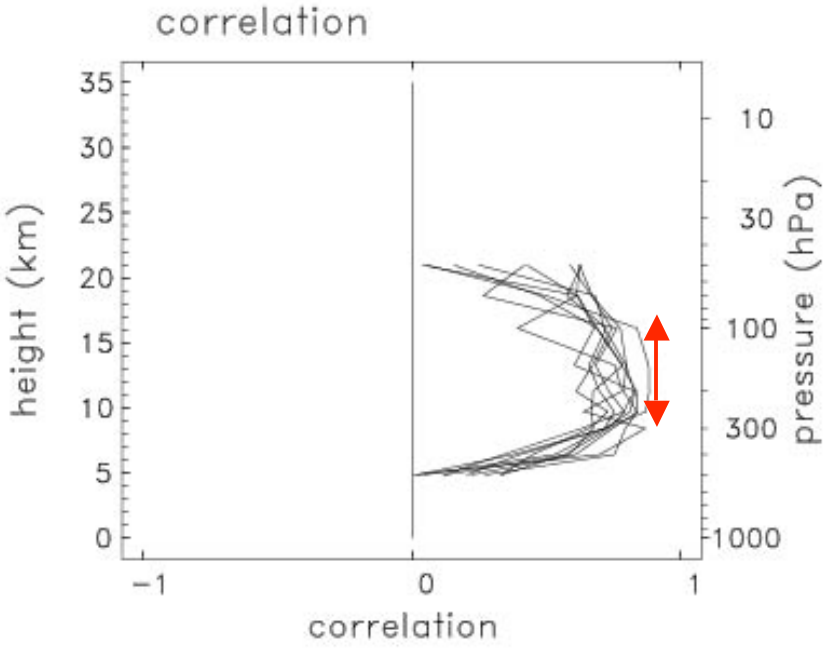
AIRS – ozonesonde correlations at 9 stations:

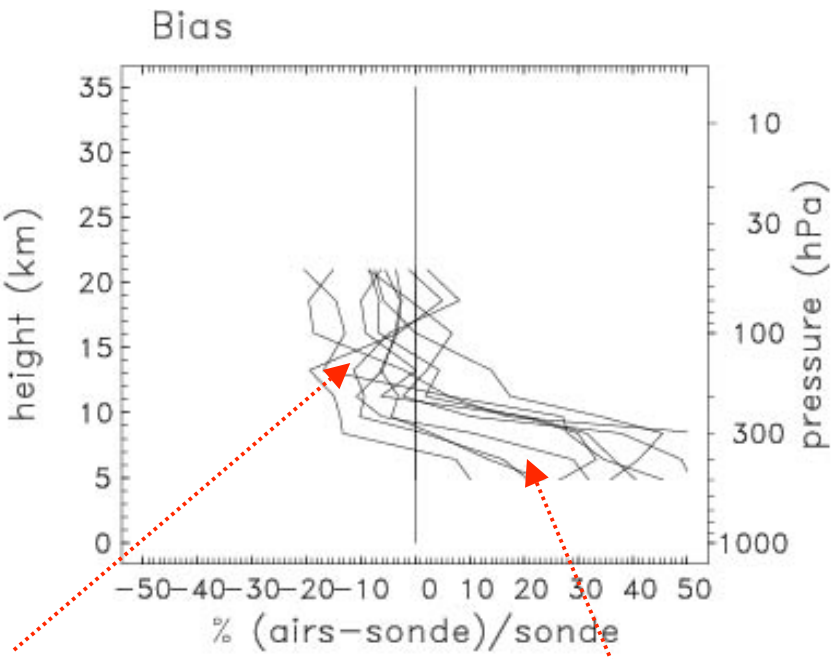


Station	#
Boulder	122
Payerne	442
Sapporo	128
Tateno	149
Edmonton	104
Goosebay	84
Churchill	75
Resolute	46
Lauder	135

high correlations
at each station
over ~100 – 300 hPa

AIRS – ozonesonde correlations and biases (9 stations, 2003-2005)

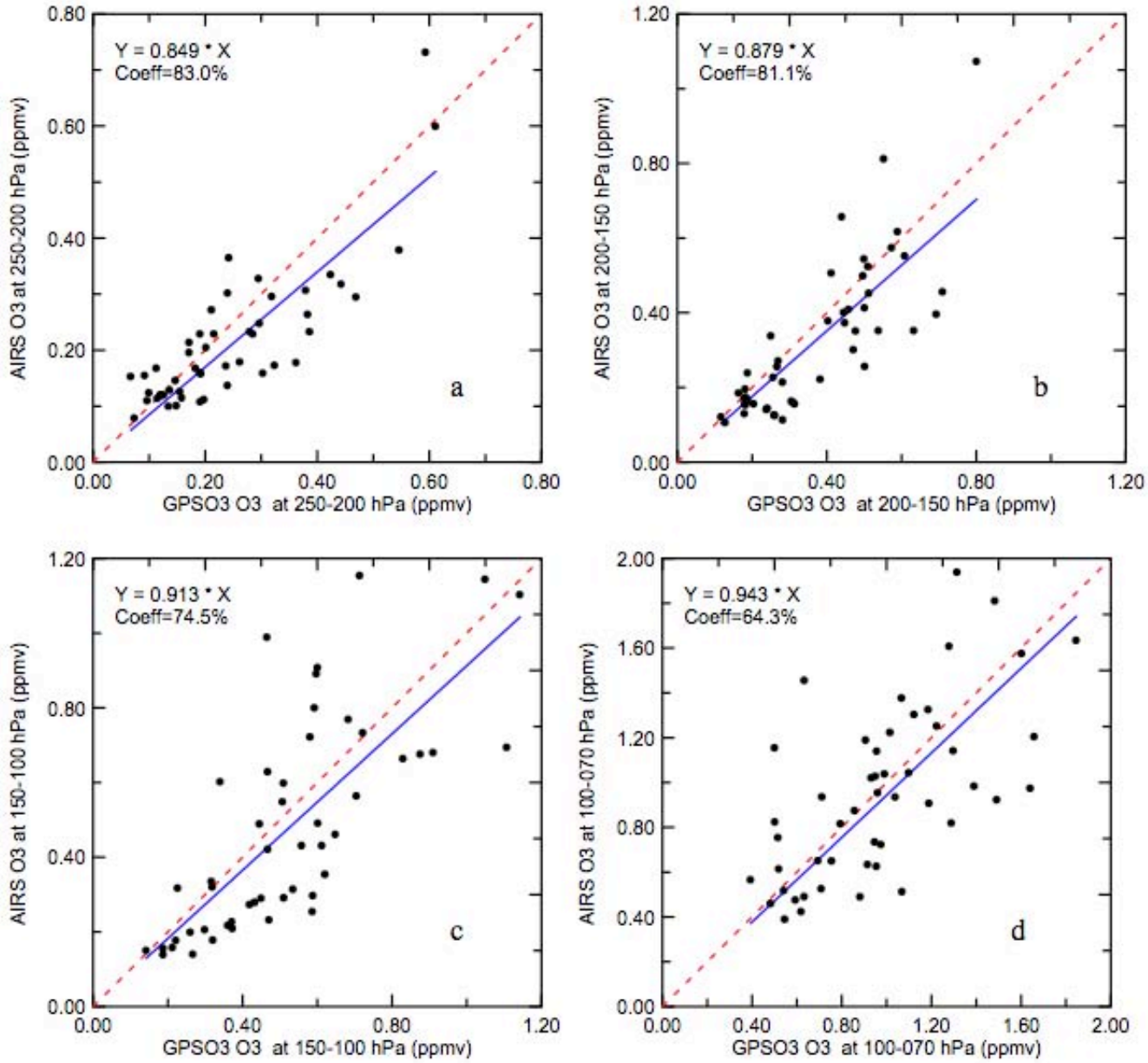


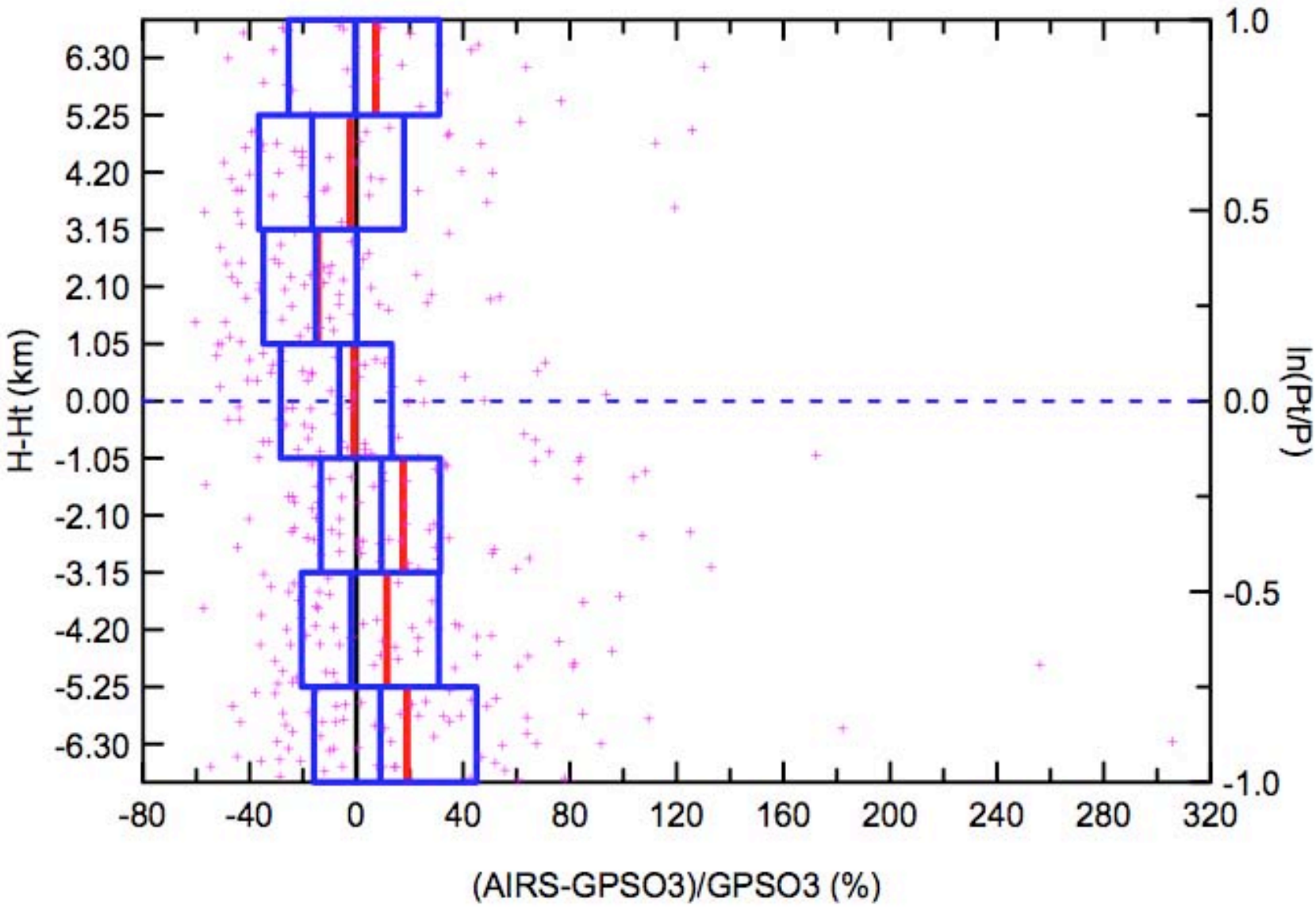


small AIRS low bias

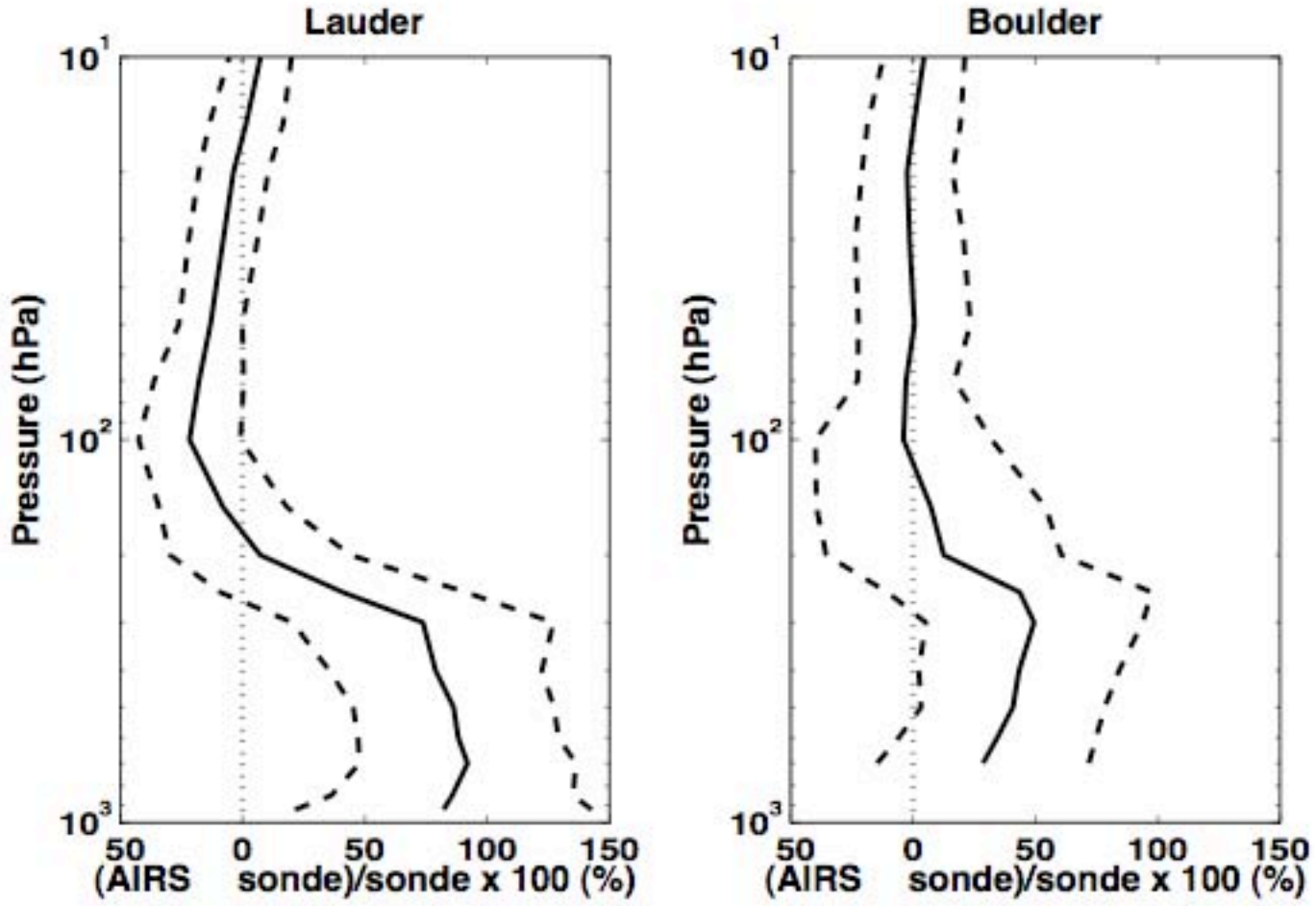
significant AIRS high bias below ~ 250 hPa

Beijing Ozonesonde comparisons [Bian et al., 2006]

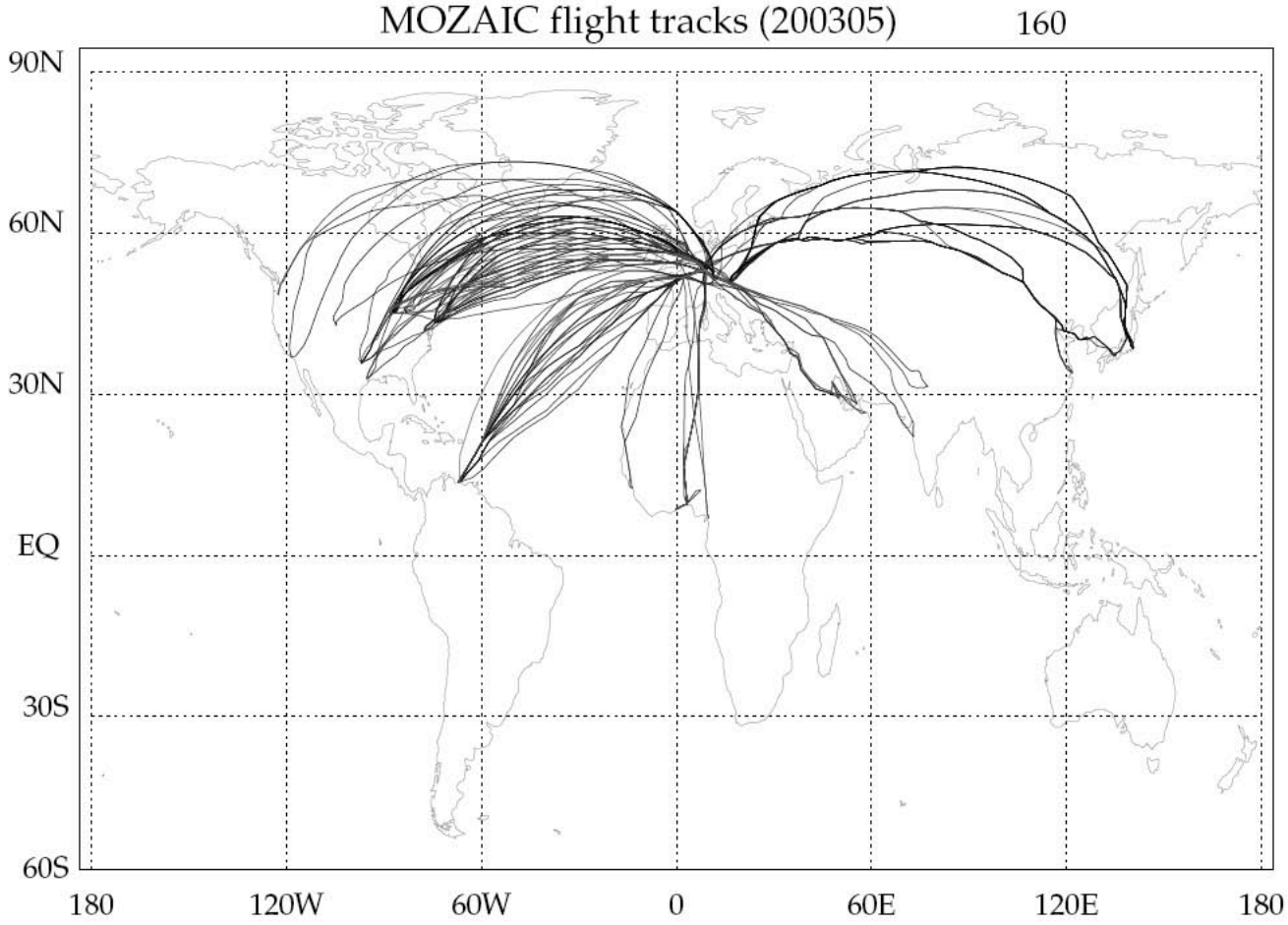



6.30
5.25
4.20
3.15
2.10
1.05
0.00
-1.05
-2.10
-3.15
-4.20
-5.25
-6.30
H-Ht (km)
1.0
0.5
0.0
-0.5
-1.0
ln(Pt/P)
-80
-40
0
40
80
120
160
200
240
280
320
(AIRS-GPSO3)/GPSO3 (%)

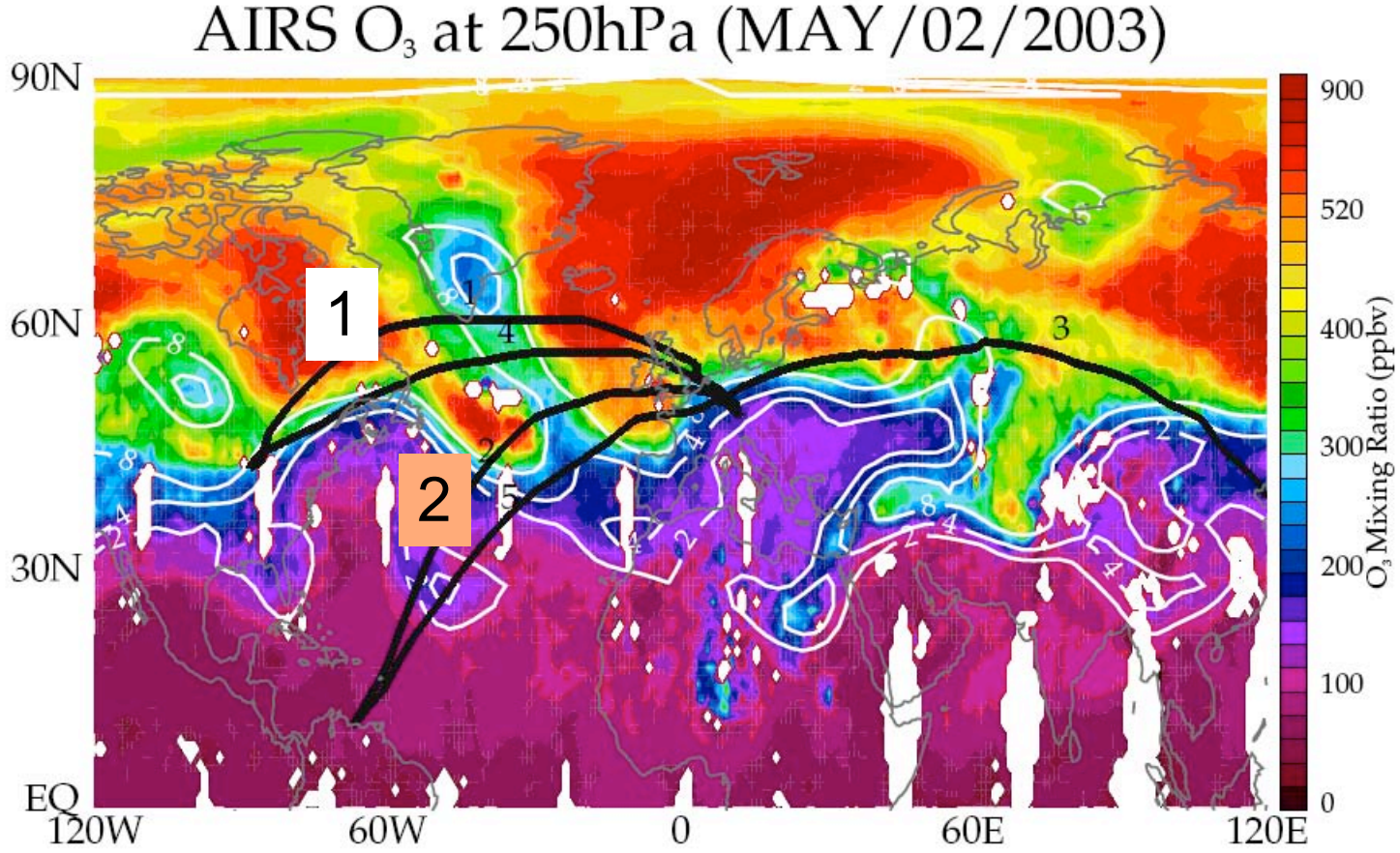
We have found an asymmetry between NH and SH retrievals – there is a larger (high) bias in SH tropospheric ozone values. The reason for this bias is likely associated with the bias in ECMWF A Priori



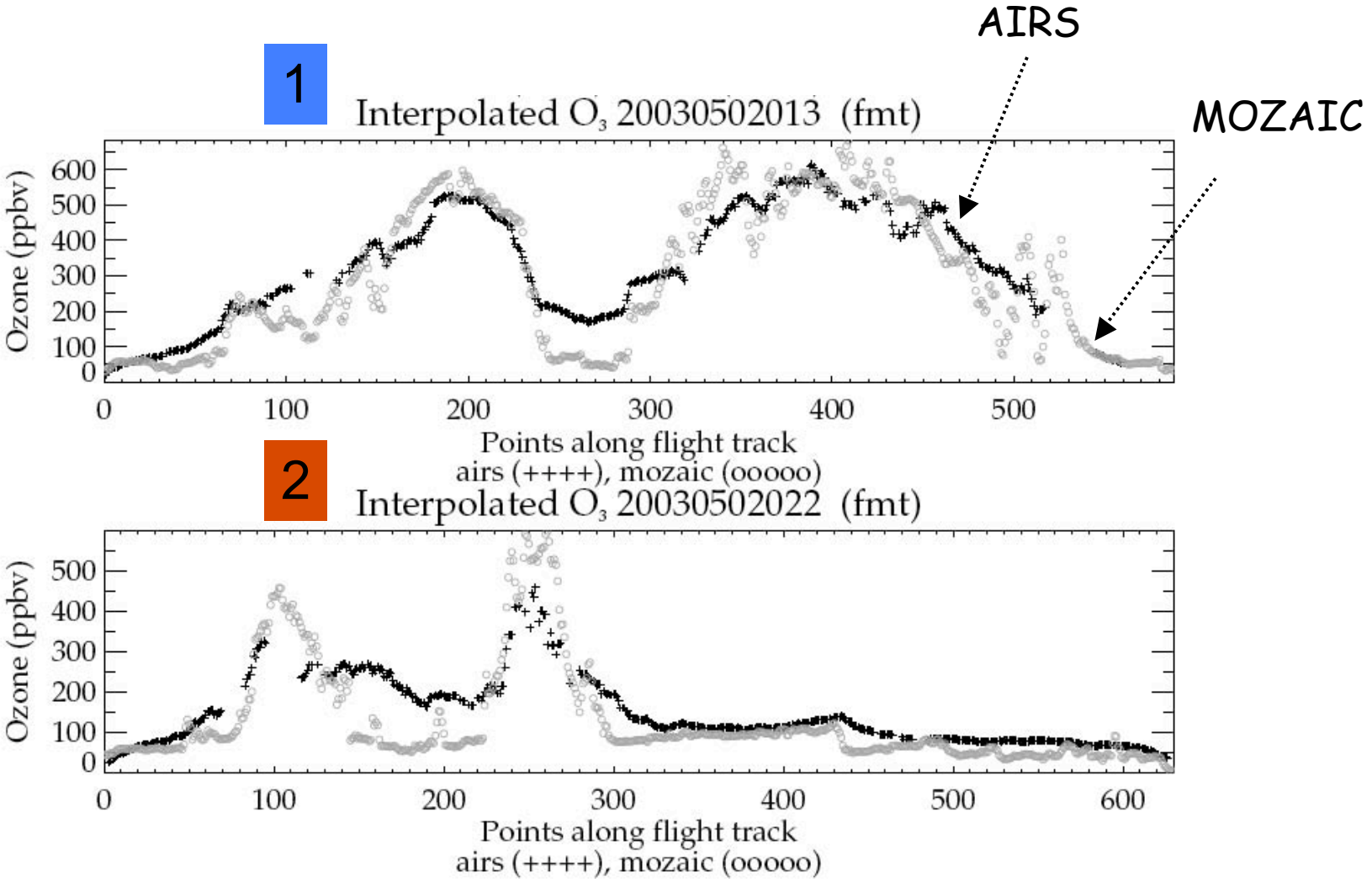
MOZAIC flight map (05/2003)
160 flights this month



AIRS O_3 vs. MOZAIC flights for one day



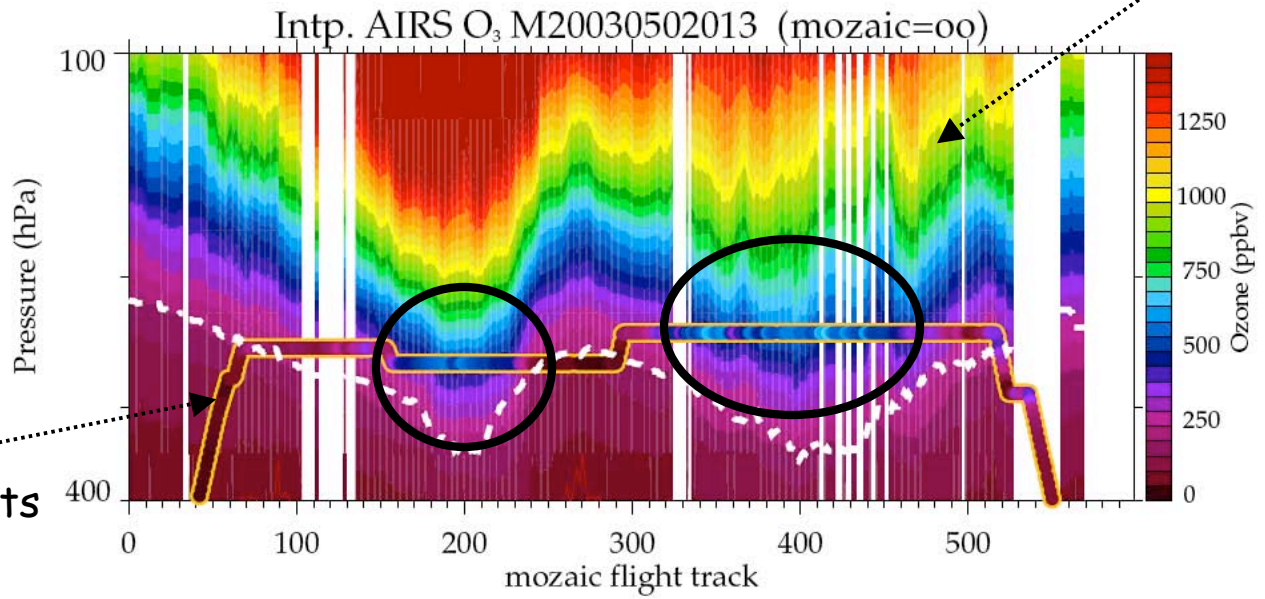
AIRS vs. MOZAIC O_3 profiles



Time vs. altitude sections

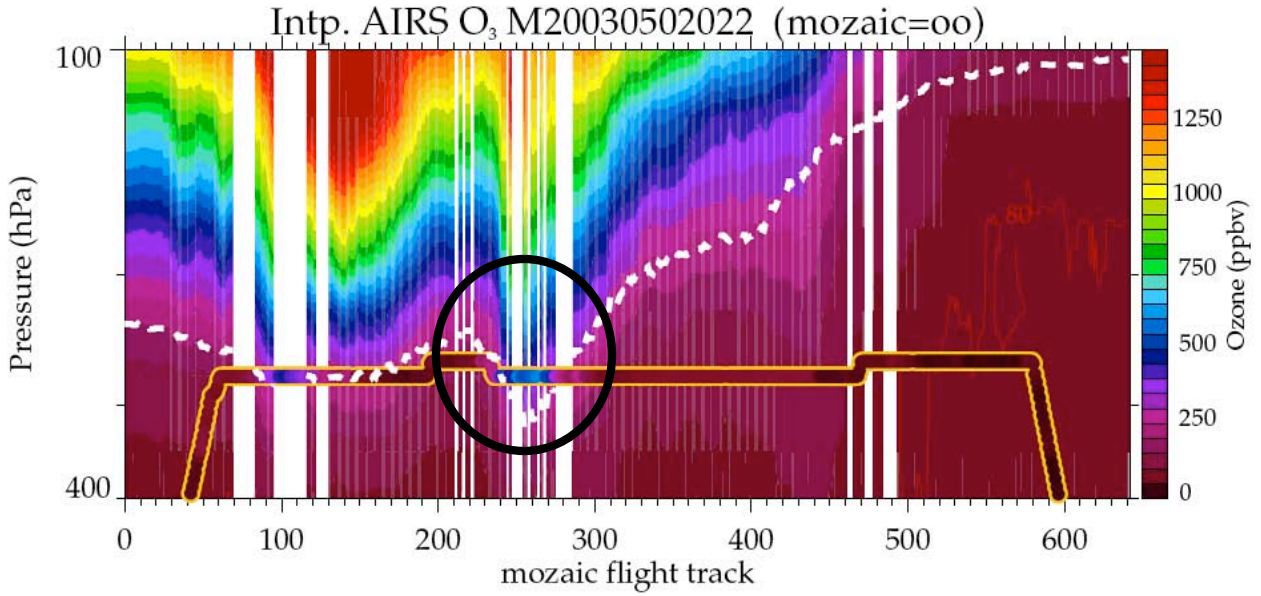
curtain from AIRS

1



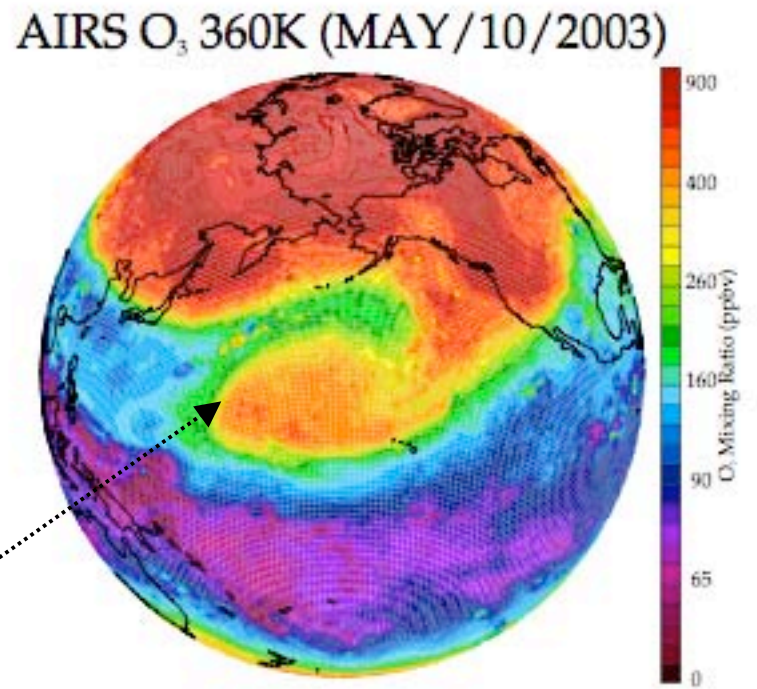
MOZAIC measurements

2



Overall comparisons suggest that AIRS v4 ozone is quite reasonable for levels ~300-100 hPa.

We anticipate using AIRS ozone to study space-time variability of the tropopause and UTLS transport

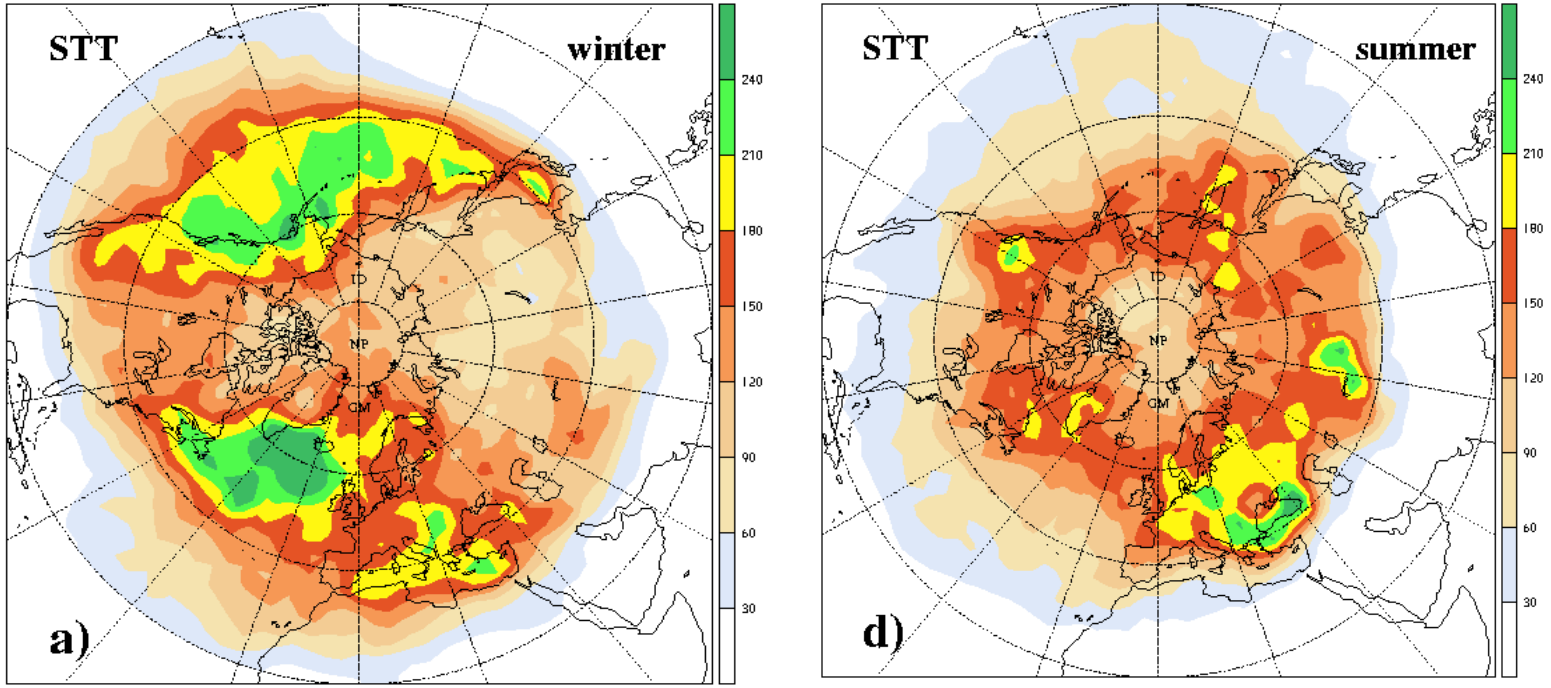


large wave-breaking event near tropopause

Lagrangian Models – preferred locations

ERA15 climatology: STT

Winter vs. summer

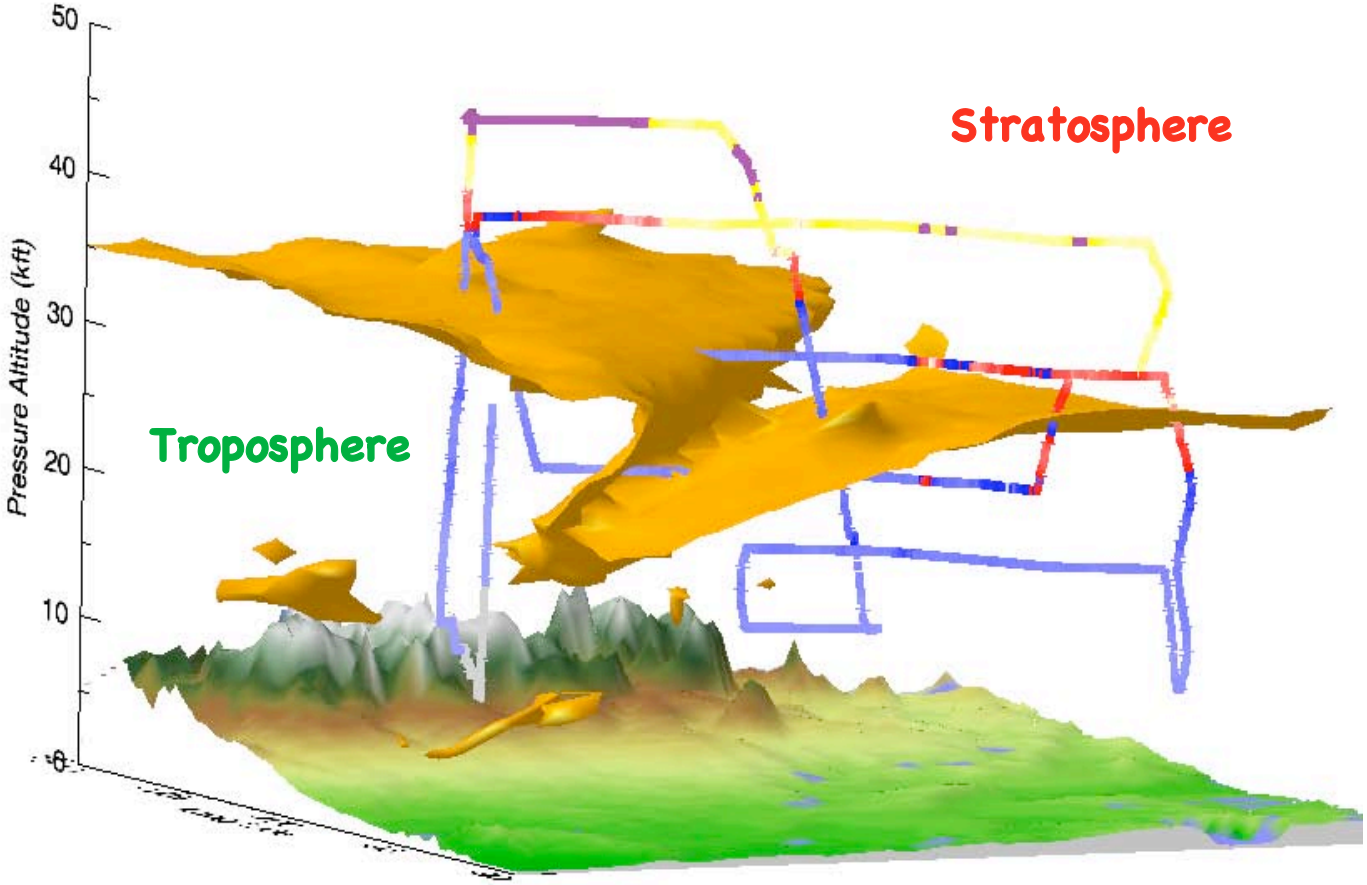


Sprenger and Wernli 2003 (JGR)

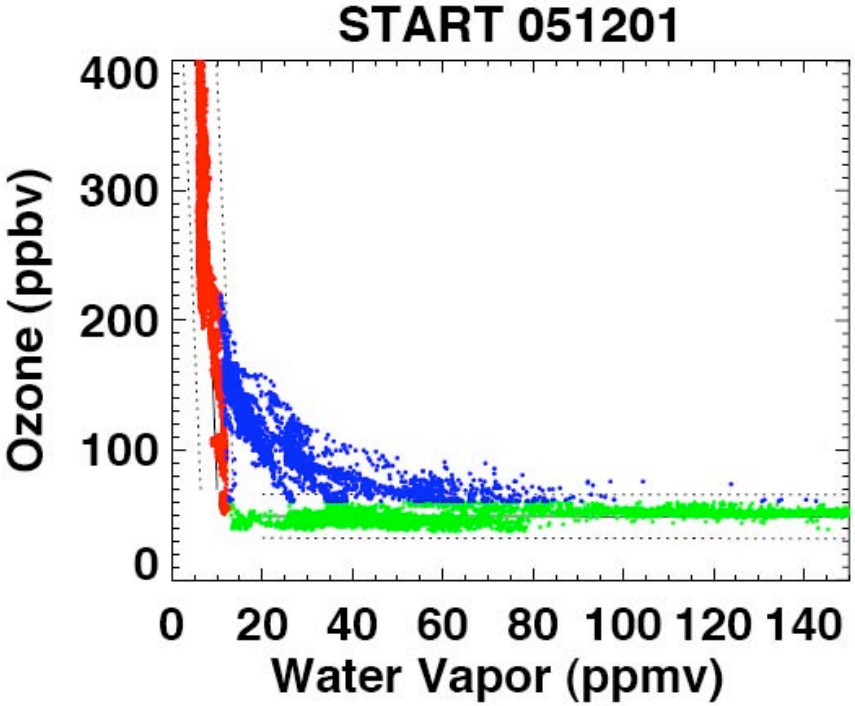

HIAPER Progressive Science Mission
Stratosphere-Troposphere Analyses of Regional Transport (START) Experiment
(December 2005)
N677F
National Center for Atmospheric
DAYBREAK BEFORE TAKE OFF 2005-12-21

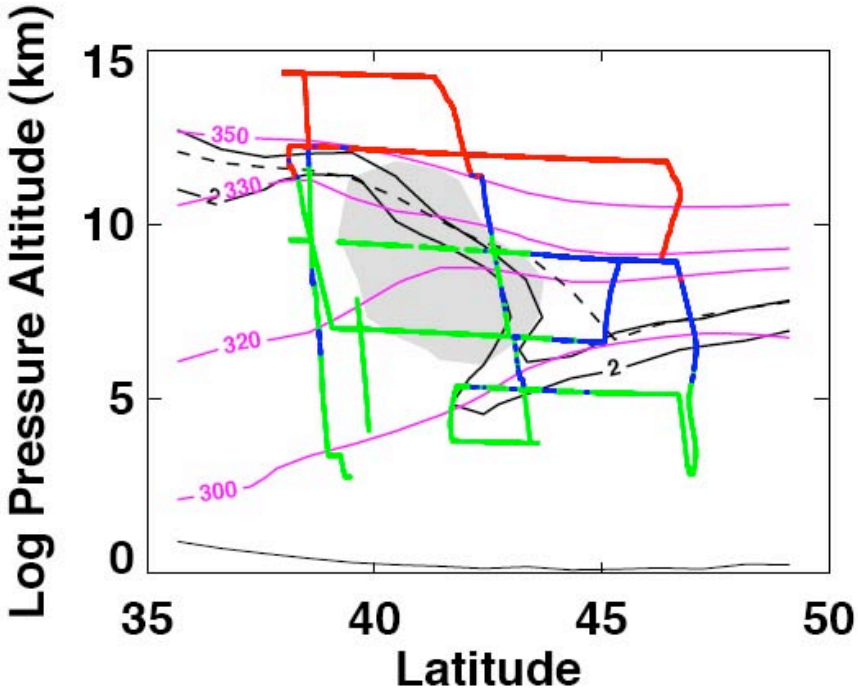
Tropopause Fold Sampled by HIAPER

First research flight of HIAPER, 2005-12-01

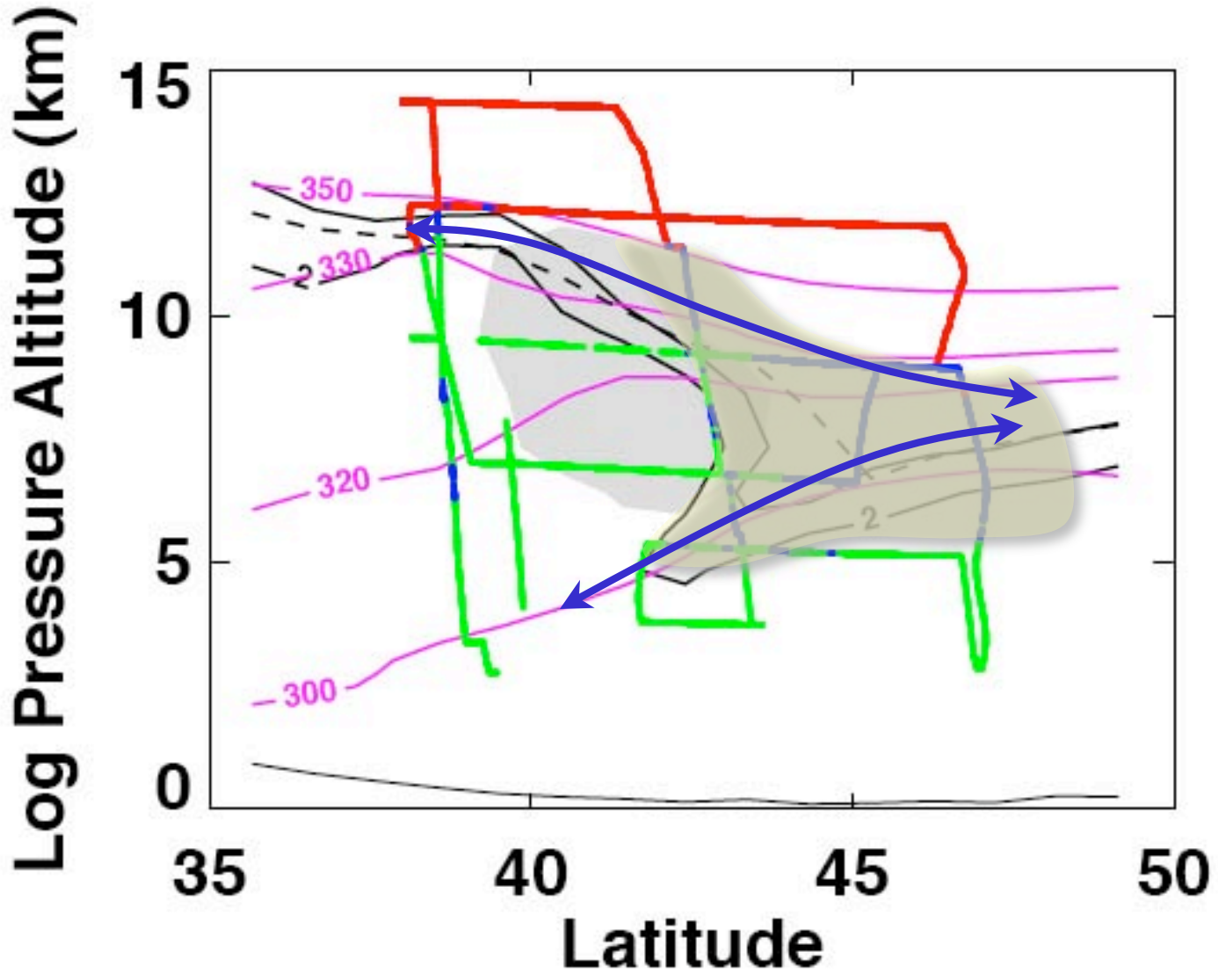


The yellow surface represents dynamical tropopause (2 PVU) from NCEP GFS analyses. HIAPER flight track is colored by *in situ* ozone values


START 051201
Ozone (ppbv)
400
300
200
100
0
0 20 40 60 80 100 120 140
Water Vapor (ppmv)

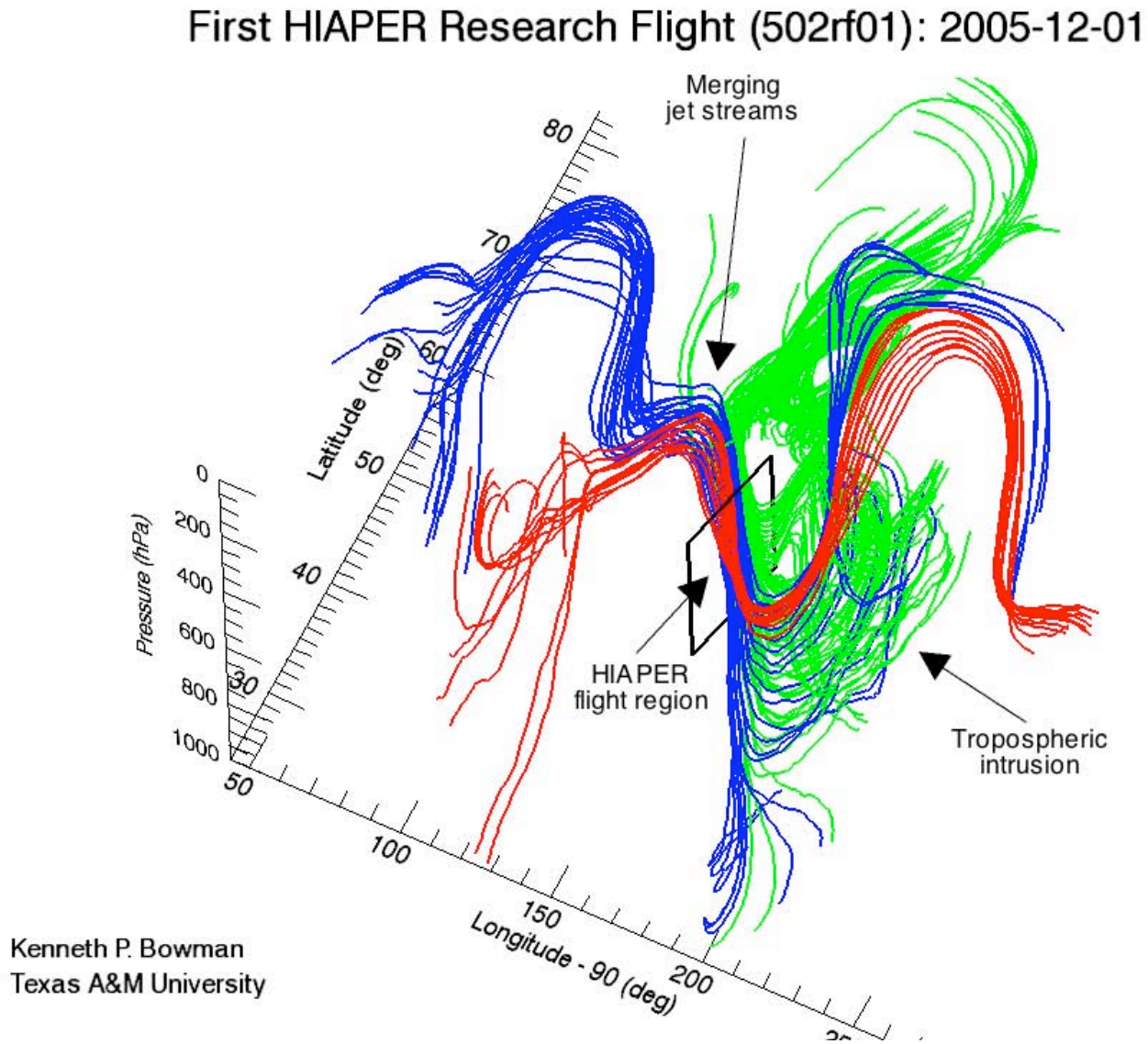

Log Pressure Altitude (km)
15
10
5
0
35 40 45 50
Latitude
350
330
320
300
2
2

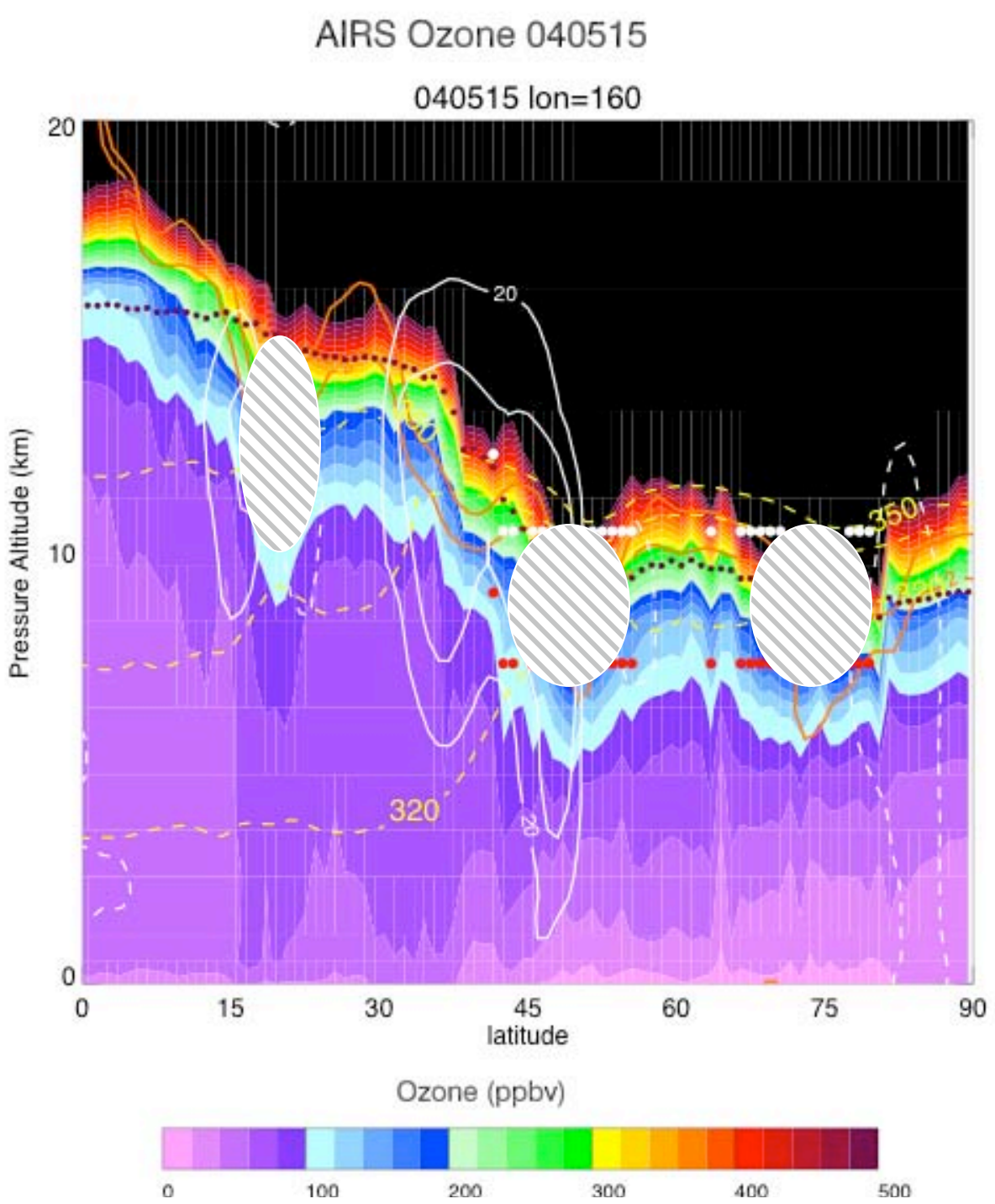
Separation of the Thermal and Dynamical Tropopause and Mixing

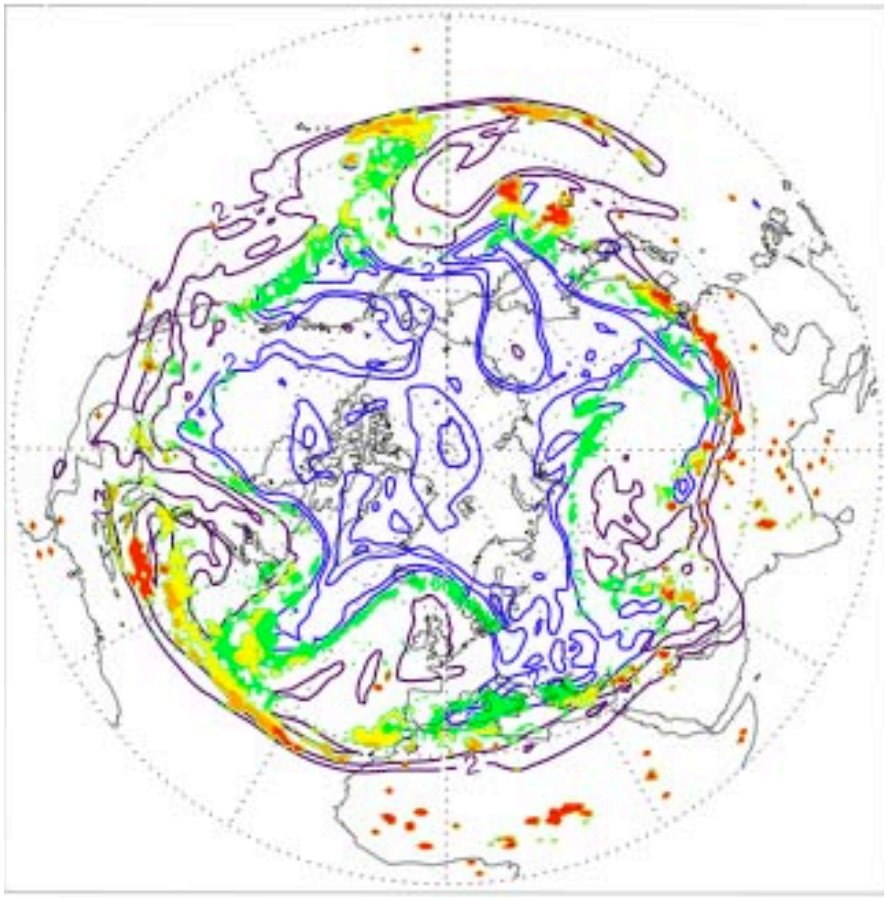


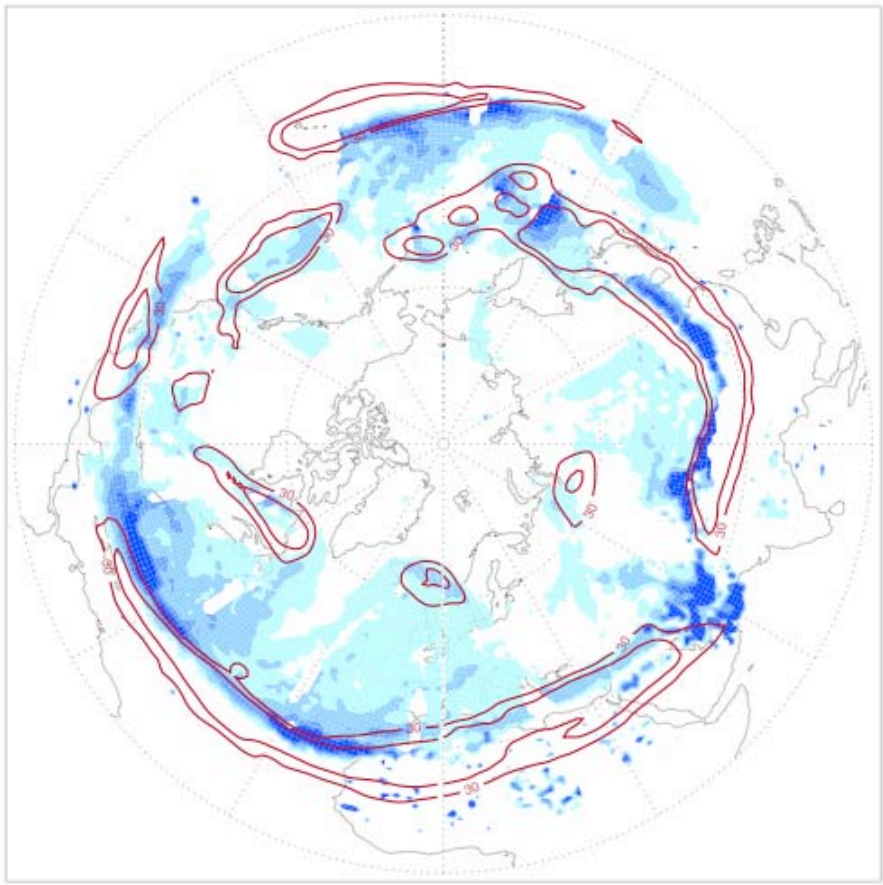
Origins and the fate of the airmass inside the intrusion

(3 days backward and forward trajectories of the air parcels in the fold)

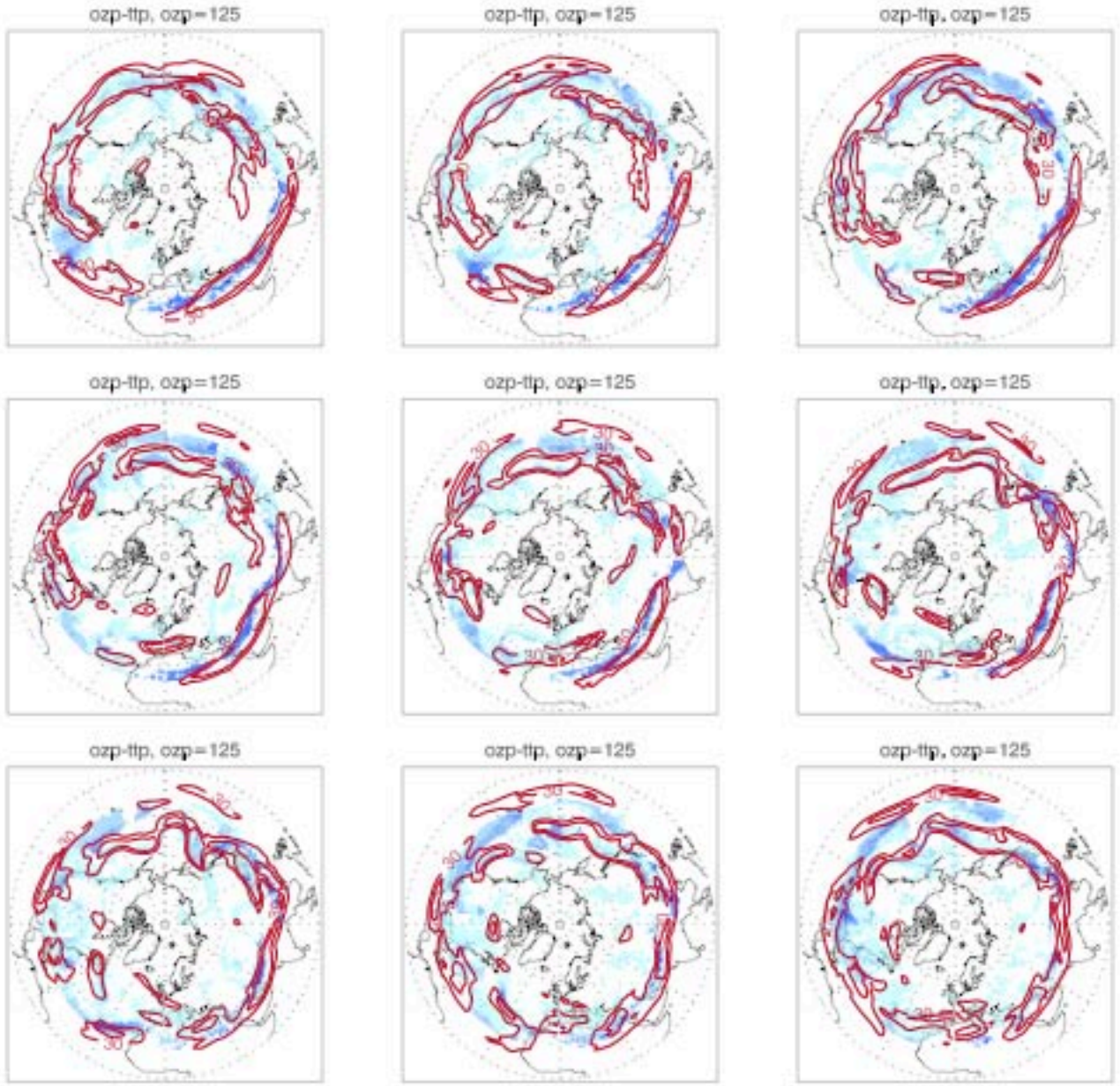



AIRS Ozone 040515
040515 lon=160
Pressure Altitude (km)
20
10
0
0
15
30
45
60
75
90
latitude
20
350
320
Ozone (ppbv)
0
100
200
300
400
500



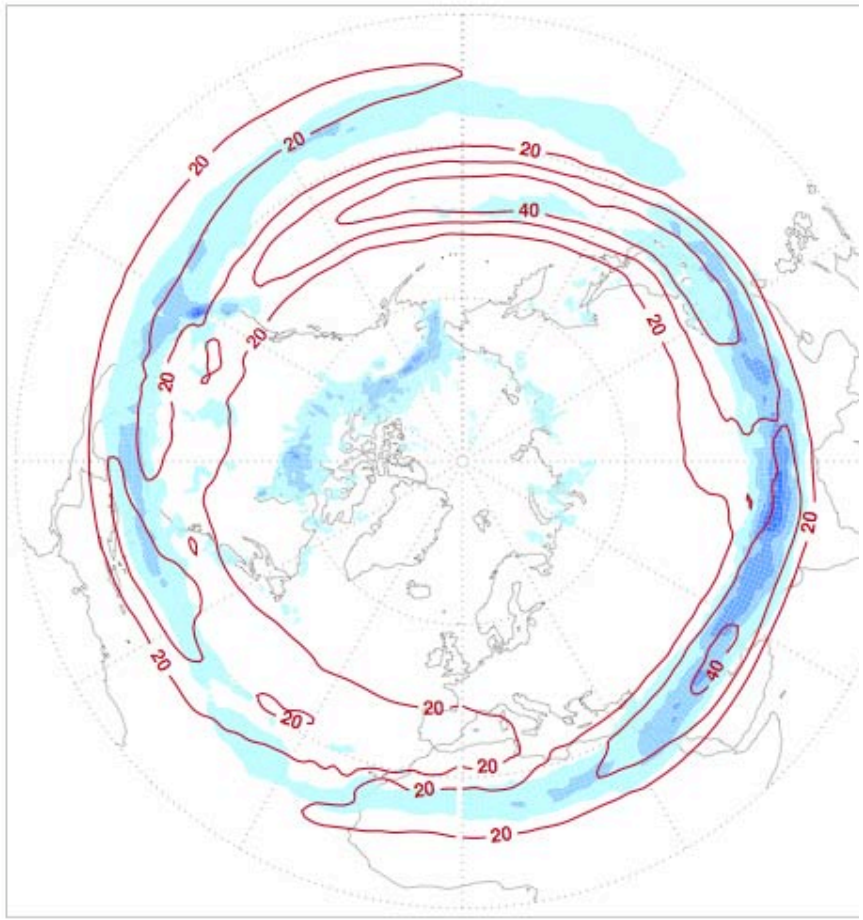


Preferred STE location in NH by AIRS, May 1-9, 2005

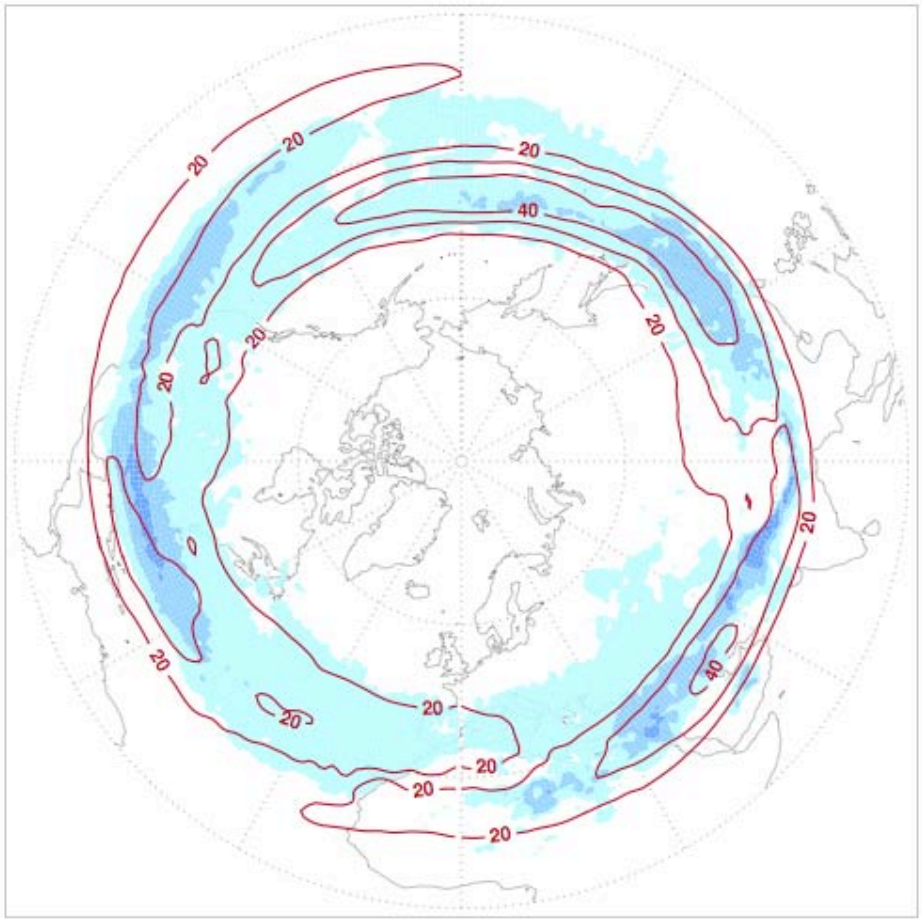


Preferred STE location in NH by AIRS, monthly mean May 2005

Dynamical Tropopause (2PVU)



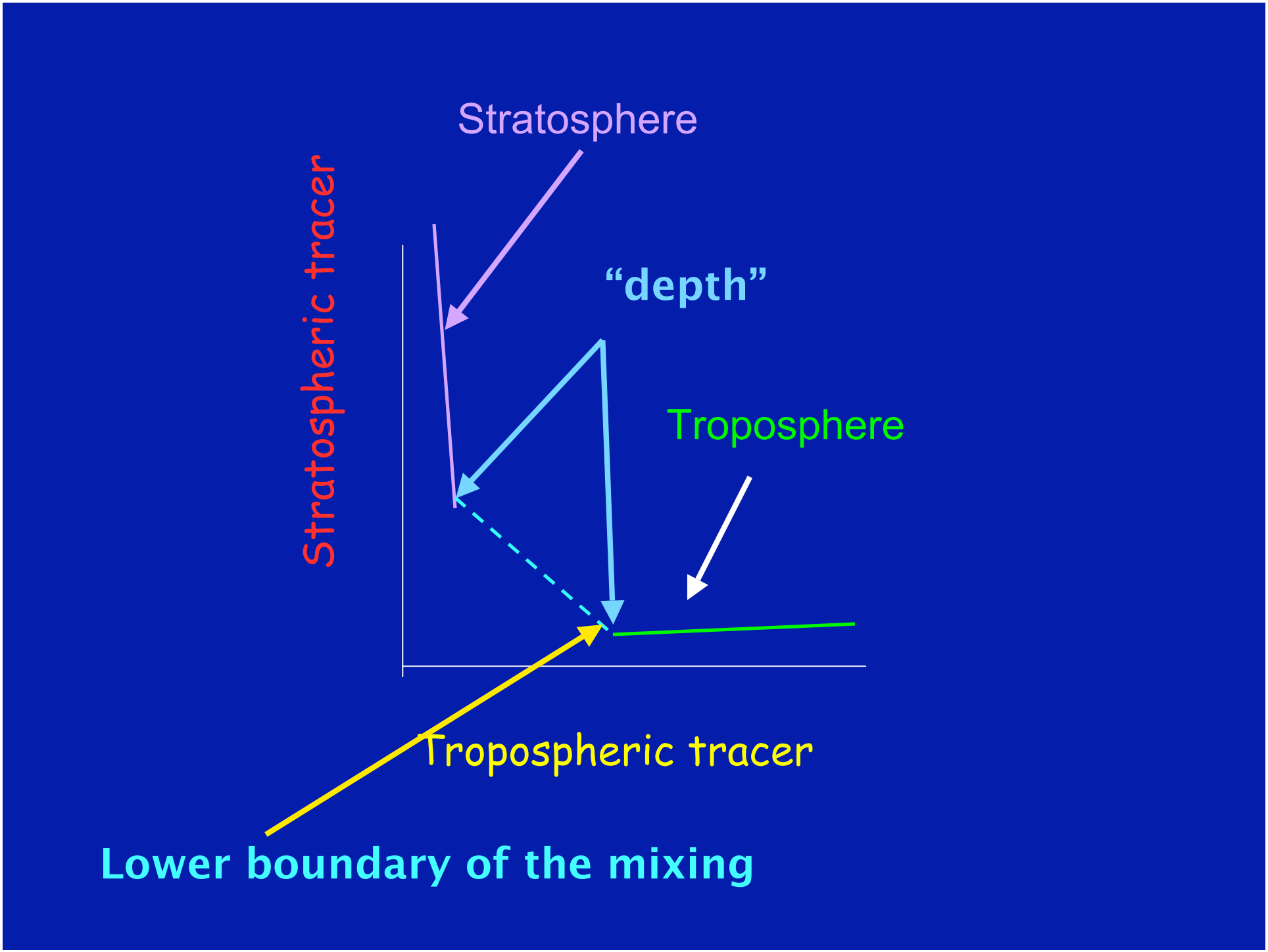
Ozone tropopause (oztp=120 ppbv)



Summary

- AIRS v4 ozone show significant correlation with sondes between 300-50 hPa range, with the best accuracy near the extratropical tropopause.
- Significant high bias in the mid troposphere and a small low bias in the lower stratosphere.
- Current ozone data is very valuable for characterizing the dynamical variability of the ozone in the extratropical UTLS, including stratosphere troposphere exchange.
- How well the data can be used to study deep stratospheric intrusion into troposphere and transport in the troposphere is uncertain.
- An improved characterization of retrieval information content is highly desirable.


Thank You!


Stratosphere
Stratospheric tracer
"depth"
Troposphere
Tropospheric tracer
Lower boundary of the mixing